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Automotive

Magneto Ignition

· M. E. Toepel ·

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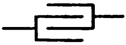
Symbols.

 Contact Points.

 Primary Winding.

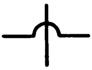
 Secondary Winding.

 Condenser.

 Ground.

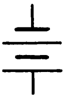
 Switch.

 Connection In Wiring.

 Crossed Wire, Not Connected.

+ Positive.

− Negative.

 Battery.

 Resistance.

 Generator, Commutator & Brushes.

AUTOMOTIVE MAGNETO IGNITION

ITS
PRINCIPLE AND APPLICATION

WITH
SPECIAL REFERENCE TO AVIATION ENGINES

BY

MICH. E. TOEPEL

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PREFACE

In compiling this work it has been the endeavor to provide a ready reference on the subject of magneto ignition as applied to automotive engines.

The rapid expansion of the practical application of electricity for the purpose of ignition renders it difficult to give a concise description of all details involved, consequently this work treats principally on the most efficient type of ignition, namely, the magneto.

There is no doubt that one of the influential factors in the development of aviation engines is due to the remarkable efficiency and reliability of modern magneto ignition. It has demonstrated that the super-power developed by the present day aviation engines is possible on account of the unfailing spark which nothing but a magneto can produce.

The superiority of magneto ignition in this field stands out prominently inasmuch as that one of the cardinal features is that it is entirely self-contained, requiring but a small amount of energy from the engine to produce a powerful spark.

It was decided to publish this work in the form of a questionaire, in order that the reader may easily grasp the principles of a complex, but in-

teresting subject. Another advantage is thereby obtained, that any particular subject may be easily referred to.

The author has had twenty-one years of practical experience in the ignition field, in addition acting as Instructor of the U. S. Government Magneto Instruction School.

It has been the endeavor of the author to avoid reference to any specific type of apparatus and minute details for several reasons—partly because the object of this work is to set forth the general principles of magneto ignition, also because any detail desired may be obtained in the literature provided by the manufacturers of ignition devices.

It would be impossible to give in the compass of this volume a description of every modification and avoid confusion by the elaboration of small features.

The knowledge of the principles of ignition involves the study of many diverse subjects, as batteries, carburetors, etc., consequently the information contained herein, except when referring to aviation engines, is equally applicable to other automotive engines of the internal combustion type.

New York

LIST OF ILLUSTRATIONS

Magneto sparks over a 6 m/m air gap.

1. What is implied by the term ignition?

The ignition of a combustible body is the result of a form of kinetic energy in which molecular movement takes place, these violent molecular movements produce heat and a corresponding rise in temperature, which if continued, will cause the body to glow and the emission of light begins in the form of red rays, this continues until a point is reached where inflammation is affected.

2. What is necessary to produce ignition?

In every form of ignition; means must be used to permit the kinetic molecular energy to develop sufficient heat to cause the rise in temperature necessary to produce ignition, this is only possible through the expenditure of energy in some form. It is evident that the principle of ignition depends upon the development of heat.

3. What is the evolution of combustion?

The potential forms of heat and light when simultaneously produced may be called inflammation, and the physical change which produces this effect is called ignition.

4. How many sources of energy will produce ignition?

There are four forms of energy known at the present time, namely, mechanical, caloric, chemical

and electrical, any of which may be utilized to produce ignition.

5. What are the advantages of electricty in producing ignition?

Electricity on account of its wonderful flexibility has the advantage that it may be produced according to requirements and caused to appear in any desired form, at any place and be altered to suit the purpose in the best manner.

6. What is energy?

The power of doing work.

7. What is potential energy?

The capacity for doing work.

8. What is Kinetic Energy?

That which applies to the energy of motion.

9. What is the theory of electricity?

Electricity exists in a passive state in everything, scientists say that the atoms which build up everything are composed of two different elements—called electrons—one kind being positive, while the others are termed negative. In the ordinary course they neutralize one another and if electricity is to be utilized it is necessary to separate the negative from the positive electrons, when a current will be caused to flow. It is, however, easier to set electricity in motion in some substances than in others. Copper and most metals for instance, the electrons

move without much difficulty and they are known as conductors. In hard rubber, air, there is great resistance and they are known as non-conductors, here it may be pointed out that there is a great difference between electricity and a current of electricity. The distinction may be made clear by an analogy. We live surrounded by the atmosphere, but normally we are unaware presence until there is a change in the conditions when, pressure is brought to bear, and a wind is caused to rise which we feel. Similarly electricity remains unnoticed until it is set in motion.

There are several ways of setting electricity in motion, one of the methods of exciting an electric current is by utilizing the properties of magnetism in electric induction produced by the motion of a conductor or wire past a permanent magnet or of a magnet past a conductor.

10. What are molecules and atoms?

Molecules are tiny masses of any substance which contain the same properties of the substance. Atoms are still smaller divisions.

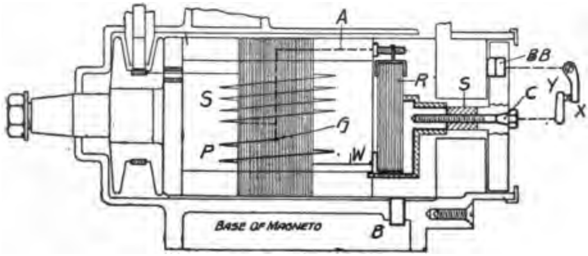
11. What is the theory of a magneto?

In the first place we have to form a conception that every magnet is surrounded by lines of force radiating from the poles, which form catenary curves that become more open and diffused as the distance from the poles becomes greater.

Second—that any conductor or wire moved so as to cut the lines of force is affected by them, con-

sequently a current is set up in the wire at right angles to the direction of motion.

Third—the intensity of the current thus generated is dependent upon the number of lines of force cut in a given time, or, what amounts to the same thing, to the strength of the magnets and to the rapidity of motion.



Current path, armature type magneto.

A—Armature.
P—Primary winding.
R—Condenser.
s—Hollow shaft.
S—Secondary winding, to collector
B-BB—Ground brushes.
X—Breaker lever, carrying platinum contact.
W—Primary and condenser connection.
C—Circuit breaker fastening screw.
Y—Platinum contact screw.
G—Primary and secondary ground.

The primary current flows from ground through the primary winding to the circuit breaker, back to ground.

The secondary or high-tension current flows from ground through the secondary winding to the distributor, to the spark plugs, to ground.

Fourth—that the most convenient form on which the conductor or wires can be arranged in order to maintain a continuous motion, is that of a cylindrical body, such as an armature.

Fifth—that instead of generating current as in the armature method, a means, such as rotating masses of iron acting inductively upon a stationary winding may be employed.

12. What is a magneto?

A mechanical device for generating electric current to ignite the gaseous mixture in the cylinders of internal combustion engines.

12-A What is the cycle of electric current as applied to a magneto?

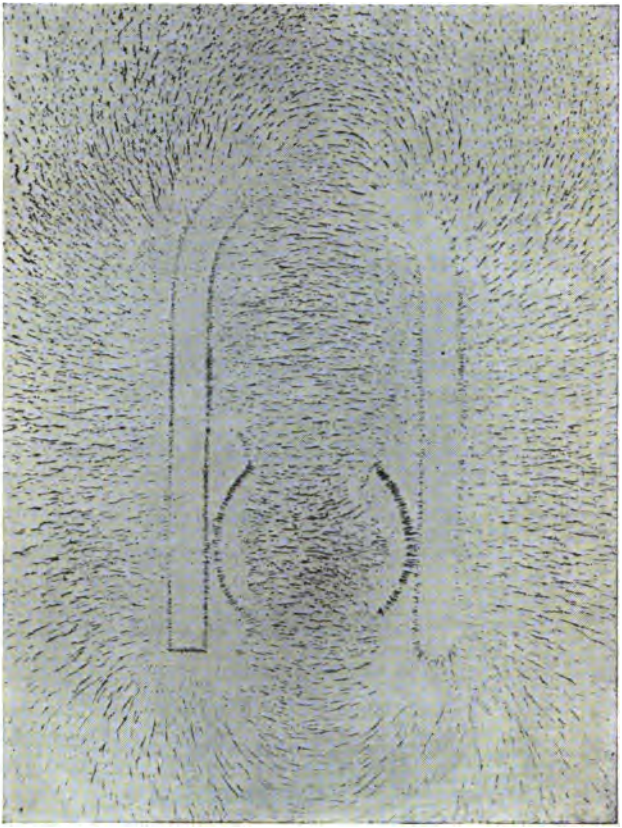
The series of changes through which the current repeatedly passes in one revolution of the armature.

12-B What is induction as applied to a magneto?

An electric current produced in a conductor by the variation of the magnetic field in its vicinity.

13. What is a high tension magneto?

A high-tension magneto is self-contained, that is; it has both the primary and secondary winding, necessary for the production of the spark, either wound on a shuttle type of armature or the primary and secondary winding may be stationary as in the inductor type magneto.



Stray magnetic field in an armature type magneto, the armature in a horizontal position, the magnetic flux flowing from the north pole at the right to the south pole.

14. What is meant by the term high-tension?

The induced current of the secondary winding.

15. What are the principal parts of a high-tension magneto?

Magnets, winding, circuit breaker and condenser.

16. What is magneto-electricity?

Electricity which is produced by the motion of a magnet past a conductor or that of a conductor past a magnet.

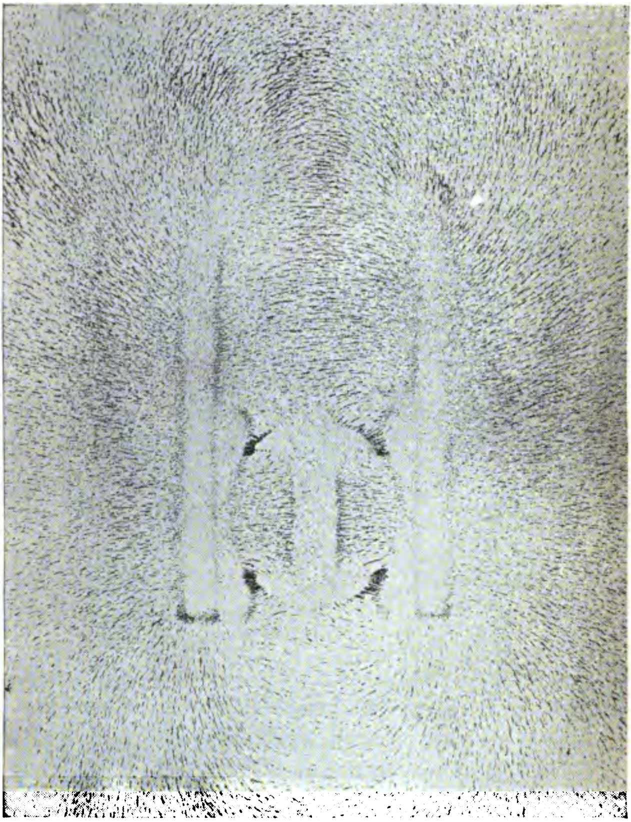
17. What is the principle of operation of a magneto?

When the armature rotates, the instrument is designated as a rotating armature type of magneto, —except when special pole shoes are employed— the flux reversals occur every 180 degrees and the magneto generates two sparks per revolution.

When the iron core is fixed, the rotor which is of iron and is so disposed that every 90 or 180 degrees—depending on the number of sparks per revolution—the flux flowing from the north pole of the magnet to the south pole—through the rotor —is suddenly reversed.

18. What is the cycle of operation in a high-tension magneto?

The cycle of operations in a high-tension magneto are as follows, the rapid reversals of flux in the iron core induce in both primary and secondary winding an alternating electro-motive force, the maximum being reached for any given speed when the actual flux in the iron core is substantially zero. The cam operating the breaker lever is so designed that the primary circuit is closed during the period



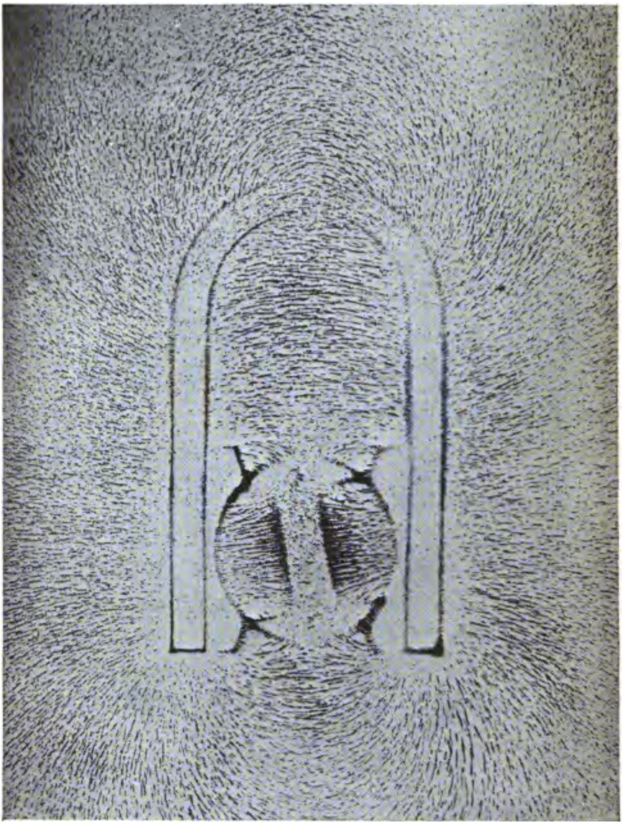
Stray magnetic field of an armature type magneto, armature is in a vertical position, the magnetic flux is at zero through the winding, as the polarity of the armature is about to reverse.

when the induced voltage is growing from zero to its maximum value, and for some little time afterwards, but not until the voltage has become zero again.

During the period of closing the primary circuit the induced current rises steadily in value. Then at a predetermined instant the contacts are suddenly separated by the cam. The condenser is in parallel with the contacts and insures that there is no arcing at the contacts at this instant, consequently the rupture of the primary current is almost instantaneous.

The sudden rupture of the primary current causes an instantaneous collapse of the magnetic field, and as the field is surrounded with secondary turns, an enormous voltage is induced in the secondary winding at this instant. This voltage is sufficient to cause a spark to jump between the electrodes of the spark plug, and this spark is maintained to some extent by the voltage induced in the secondary by the reason of the continual flux change in the iron core produced by the rotation during the period that the contacts remain separated. After a short interval of time the cam permits the contacts to close again and the cycle of operation is repeated.

There is an important part of the magneto, namely, the condenser, although an essential part of the magneto, plays a purely subsidiary part, and if it were possible to break the primary circuit quickly enough it would be unnecessary and the magneto would in fact, be better without it. The purpose of the condenser is to delay the production

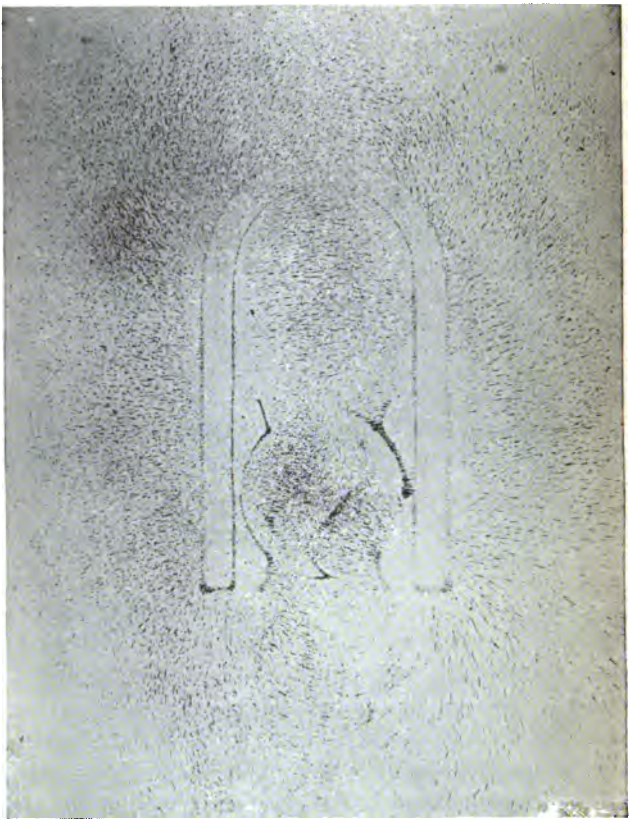


Stray magnetic field of an armature type magneto, the armature in a position when the contact points of the circuit breaker are about to separate.

at the contact points of the voltage due to the rapid initial movement of the lines of force. If it were not for this delay the voltage would be manifested at the platinum points before they had time to separate properly, consequently arcing at the platinum points would ensue, the circuit would not be broken cleanly and sharply and burning of the contact points would occur. The condenser obviates this by absorbing the initial current rush and preventing the voltage from building up to an appreciable value before the contact points have had time to separate properly, but at the same time that it retards the development of the primary voltage it retards that of the secondary voltage also, so that its capacity should not exceed the minimum necessary for the successful suppression of the sparking at the contact points.

19. What is termed the induced secondary voltage of a magneto?

Prior to the occurrence of the break, a certain amount of energy is stored in the primary winding by virtue of the magnetic field associated with the current induced in the winding by rotation. The magneto is so designed that at the instant when the contacts separate, this energy can be transformed magnetically to the secondary winding to reappear at the electrodes of the spark plug in the form of a high-tension discharge at a very much higher potential. The rate at which the secondary voltage rises and the maximum value reached are dependent on the primary current broken, on the self-induction of the primary at the time of the



Stray magnetic field in an armature type magneto, armature has advanced about 45 degrees, the magnetic flux passing through the winding.

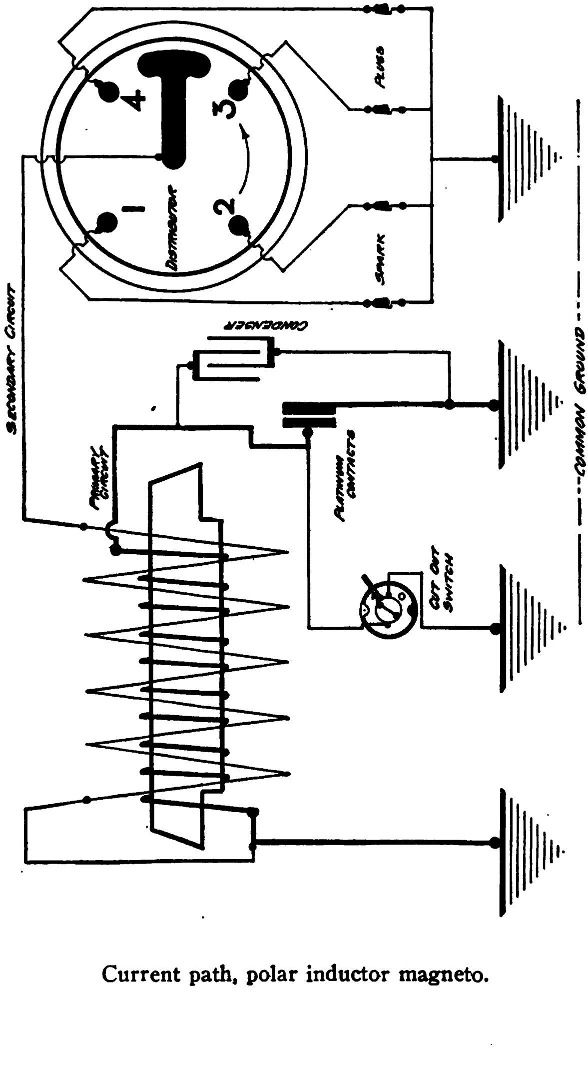
break, on the ratio of turns of wire, and on the characteristics of the magnetic circuit. In other words it is necessary that the magnetic field created by the primary current shall instantly collapse at the time of the break. Obviously, the rate at which the magnetic field disappears is, other things being equal, vitally dependent upon the characteristics of the magnetic circuit through which this magnetic field is passing. This means that the magnetic circuit that is completely laminated will insure a more rapid dying away of the magnetic field than would occur if there are in the magnetic field any solid masses in which eddy currents may be set up during the period of change, these eddy currents by their reaction tending to retard the rate at which the collapse of the magnetic lines occurs.

20. What are the principles of magneto ignition?

The function of the magneto is to produce the ignition of an explosive charge in the cylinder of an internal combustion engine.

It is possible to regard the spark given by a magneto or other electric appliance as being simply a small source of intense heat and the rate of flame propogation in an engine cylinder depends to an appreciable extent on the available energy in the ignition spark and consequently the horse power developed in an engine, provided the spark is of sufficient intensity to insure good ignition, but if the mixture is too weak and the spark intensity is too low, misfiring may occur, in which case the horse power drops off.

Under starting conditions, however, the problem



Current path, polar inductor magneto.

is more difficult, as it certainly requires more energy to ignite a cold gas than a hot one, especially if the fuel used is rather heavy so as to be present in the cylinder in the form of a spray or mist rather than a vapor.

Let us therefore consider the magneto as an instrument which has for its main object the sudden liberation of a definite amount of energy in the engine cylinder in the form of a spark.

This energy, which is derived in the first instance from the mechanical energy given by the engine is transformed in the magneto itself into electrical energy, and transformed back into heat energy at the spark plug, and we have to consider in detail the means by which a magneto transforms mechanical into electrical energy.

This electrical energy is produced by means of electro-magnetic induction. This means that if a conductor is moved in a magnetic field an electromotive force is produced in it, if the conductor or wire form portion of a closed circuit, an electric current will flow in this circuit.

The essential parts of a magneto are, first, a magnet, second, a winding, third, a circuit breaker, fourth, a condenser.

It is the function of the primary winding to produce the rapid change of flux which is necessary to induce in the secondary winding a voltage of sufficient intensity for the production of the spark. We have already stated that if a magnet be moved past a conductor or wire so as to cut the lines of force a voltage will be induced in it, and, that if the conductor or wire forms portion of a circuit an electric current will flow in it.

21. What is a low-tension magneto?

In this type there is but one winding and requires a transformer to step the low-tension current to high-tension or the low-tension current may be used direct for make and break ignition.

22. What is the principle of a low-tension magneto with a transformer?

In a high-tension system of ignition employing a low-tension magneto, the principle of operation is based on the extra current produced at the moment of opening of the platinum points of the circuit breaker.

Rotor and winding of an inductor magneto.
The winding is stationary and the rotor blocks revolve.

23. What is an inductor type magneto?

In this type, the magnetic flux is made to pass through a stationary winding, first in one direction and then in reverse way, an alternating electromotive force will be produced, and, if the terminals of the winding are connected to an outside resistance, current will flow. In the principle of the inductor

magneto, the current is induced in its winding instead of being generated in the winding when a winding is moved so as to cut the lines of magnetic force.

24. What is a polar inductor type of magneto?

When a rotor comprises iron masses of a fixed or constant polarity operating in conjunction with an iron core carrying the windings, the instrument is designated as a polar inductor type of magneto.

Flux path of an inductor magneto, a reversal of magnetic flux occurring every 90 degrees.

The path of the magnetic flux is indicated by the arrows and flows from one pole piece at the base of the magnets, through one half of the rotor block, through the winding, through the opposite rotor block to the opposite pole piece. When the rotor has moved 90 degrees, the opposite faces of the rotor will again be presented to the pole pieces, but the magnetic flow will be in the opposite direction and causes the magneto to produce an alternating current.

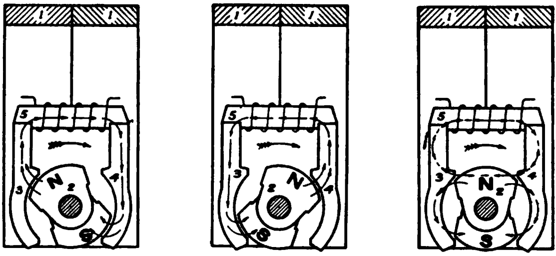
25. What is a two spark magneto?

A magneto provided with two distributors, connected to each end of the secondary winding, de-

signed to produce two sparks simultaneously at two different spark plugs in the same engine cylinder.

26. What is a sleeve inductor magneto?

A magneto which embodies a stationary shuttle type armature surrounded by a rotating sleeve. The movement of the rotating sleeve produces a change of magnetic flux through the stationary armature every 90 degrees, consequently 4 sparks are produced every revolution.



Flux path of a polar inductor magneto, a reversal of magnetic flux occurring every 180 degrees.

The rotating poles N, S are always of the same polarity, when N is opposite 3, the flux flows from N to 3 through the core of the winding 5 to 4, to S.

In the second figure the pole N has moved over to 4 and the direction of the flow of flux is reversed and flows from N to 4, through 5 to 3 to S.

In the third figure the rotating poles occupy a midway position, here the field pieces 3 and 4 are magnetically short circuited, clearing stray lines of flux out of the core 5.

27. What is meant by the term Synchronized Magnetos?

The occurrence of two sparks from two magnetos simultaneously in the cylinder of an engine.

28. What is a fixed spark magneto?

A magneto in which the relation of the magnetic break of the rotating element with the mechanical oreak of the contacts is in a fixed position, it has no timing lever.

28-A. What is a unidirectional magneto?

A high tension magneto that produces sparks of one polarity only. There are four magnetic breaks within the magneto, but owing to a modification of the cam only two sparks, both of the same polarity, are produced. In the ordinary magneto the current being alternating, sparks of negative and positive polarity are produced. (See also 199.)

High-tension starting magneto for airplane engines.

28-B. What is a starting magneto?

It is a small, geared up hand cranked magneto operating as an auxiliary scource of high-tension current, whereby a shower of sparks may be generated to produce ignition in the cylinder about to fire, through the medium of a trailing pin in

the distributor which is set a number of degrees later than the main distributor and operates in conjunction with it.

28-C. How does the secondary current flow in a high-tension magneto?

When the high-tension current emanating from the magneto passes through the center electrode of the spark plug to the engine it is termed positive, the high-tension current flowing from the grounded end of the secondary winding, through the magneto frame, engine, spark plug shell to the center electrode, cable, to the magneto, the current is termed negative.

Rotating circuit breaker with internal cams.

29. What is a circuit breaker?

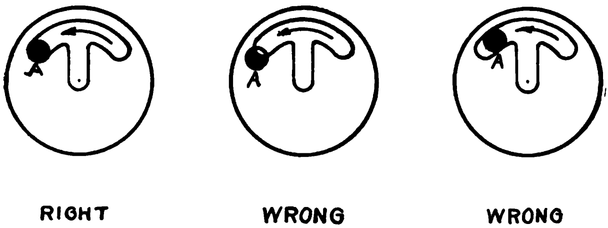
A circuit breaker is a mechanical device for opening and closing the primary circuit, having one stationary contact and one cam acuated moveable contact.

30. How does a circuit breaker operate?

The contacts are either mounted on a rotating plate and actuated by one or more cams fixed in a housing, or the contacts may be fixed on a movable plate and actuated by a rotating cam.

31. What effect has the rapid breaking of the primary circuit upon the secondary?

It has been shown by experiment, that when the primary circuit is broken by shooting a bullet through a wire, it is possible to attain a long secondary spark without a condenser across the primary circuit. With a mechanical circuit breaker the rapidity of the break is limited by the imperfection of the circuit breaker and it becomes necessary to use a condenser to prevent the destructive arcing across the contact points.



Position of carbon brush on distributor, contacts opening, timing lever fully advanced. The brush should be full on the segment, otherwise the highly finished surface of the distributor will become pitted and burnt.

32. What is a distributor?

A block of insulating material having a number of segments or carbon brushes, equal to the number of cylinders to be fired, an insulated distributing member fitted with a brush or segment by means of which the high-tension current is distributed to the cylinders in their proper firing sequence.

33. What is called dual ignition?

Dual ignition uses a transformer and one set of spark plugs with the current supplied by either the magneto or a battery, the circuit breaker and the distributor are common to both. The magneto may be either high-tension or low-tension.

Stationary circuit breaker with rotating cam.

34. What is called duplex ignition?

Duplex ignition utilizes the battery current for starting also the magneto when the engine is cranked. In this system the battery current is thrown in phase with the magneto, the battery current passing through an impedance coil, and by means of a commutator, the flow of the battery current is made to flow in the same direction as the magneto current, that is inasmuch as the magneto current is alternating and the battery current also flows in the same direction or in phase, so called.

35. What is independent ignition?

Independent ignition is a term usually applied to a self contained magneto that it is not connected to or dependent on any auxiliary source of current.

36. What does a high-tension system of ignition consist ot?

In a magneto, a primary winding in circuit with a condenser and circuit breaker, a distributor in circuit with the secondary winding, cabies leading to the spark plugs and a switch to control the action of the magneto.

37. How is a magneto timed to itself?

A magneto is timed by setting the magnetic break and platinum contacts correctly, at the same time having the distributor in full contact with the brush or segment, timing lever fully advanced.

38. How many systems of ignition are there in use at the present time?

Generally speaking, there is only one system in use at the present time, namely, high-tension.

39. How can one tell a right hand or clockwise magneto from a left hand or counter clockwise magneto?

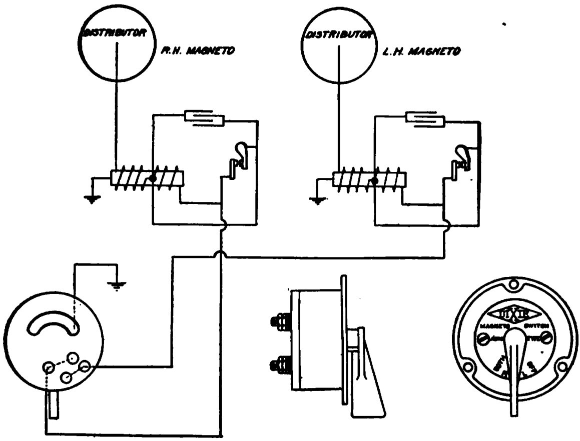
The direction of rotation is usually marked on the oil cover or some other part at the driving end of the magneto.

39-A How would you ascertain the direction of rotation of a magneto that was not marked?

By turning it and feeling the magnetic pull in relation to the opening of the contact points.

40. What is the theory of magnetism?

Magnetism is a phase of molecular motion in which the magnetizing process produces harmonious vibration of the molecules to take the same relative position whereby magnetic effects are produced. When the magnetizing process ceases, the harmonious vibration of molecules is maintained in hardened steel and in soft iron this activity disappears entirely.



Internal wiring plan, two synchronized magnetos and control switch.

41. What is the history of magnetism?

It has been said and written that the ancient Chinese were acquainted with the properties of magnetism, which they utilized in the mariners compass. The Greek shepard Magnes—so the legend goes—was unexpectedly detained by the iron

nails in his shoes being held fast to a large body of lodestone (magnetic iron ore) with which he accidentally came into contact.

The fact remains that the properties of magnetism have come to play a vital part in the ignition of the internal combustion engine.

42. What is a magnet?

A body possessing the power of attracting the opposite poles of another magnet or repelling the like poles or, having the power of attracting magnetizable bodies to either pole.

43. What is a magnetic field?

The region of magnetic influence surrounding the poles of a magnet. The magnetic field of an electric current is that which surrounds a circuit traversed by an electric current.

44. What is a bar magnet?

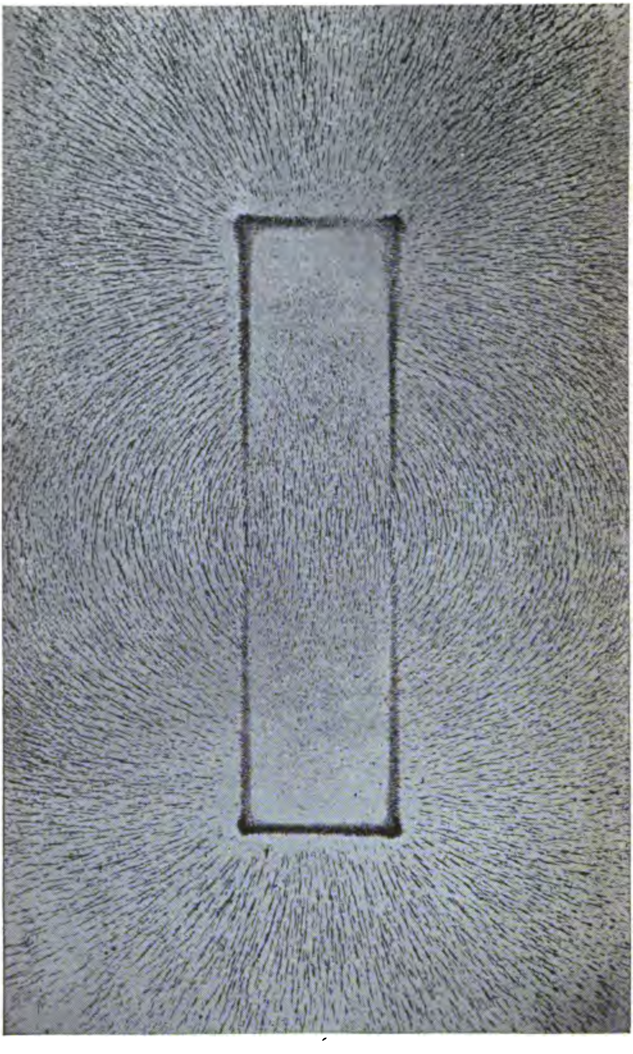
A simple magnetized bar.

45. What is a permanent magnet?

A magnet composed of hardened steel, which usually contains a small amount of tungsten, and retains its magnetism a long time after it is magnetized.

46. What is a horse-shoe magnet?

A magnet is shaped like a horse-shoe, because it was found that the greatest magnetic strength laid



Magnetic field of a bar magnet, the catenary curves become longer as the distance from the poles increases.

in the poles and its opposite poles are nearer together, consequently through the concentration of the magnetic lines of force, the poles of a horseshoe magnet offer the least resistance to the flow of the magnetic lines of force, across the air gap intervening.

47. What is a compound magnet?

A number of single magnets, placed one over another and with their similar poles facing each other.

48. What is a bell shaped magnet?

This is a modification of the horse-shoe magnet in which the approaching poles are semi-annular in shape and form a split tube.

49. What is meant by the term, magnetic Permeability?

Conductibility of the lines of magnetic force. Iron possesses this property to a greater degree as it permits the lines of magnetic force to readily pass through it, in other words the magnetic resistance of iron is low.

49-A What is called Coercive force in a magnet?

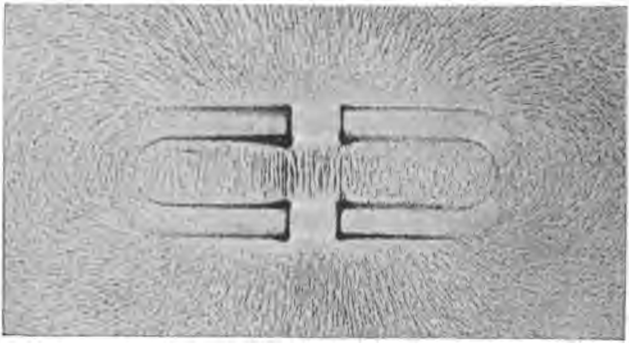
The power of resisting magnetization or demagntization. Hardened steel possesses this property to a greater degree and in soft iron the coercive force is feeble.

50. What is magnetic saturation?

When a magnetized body fails to be further magnetized no matter how great the magnetizing force.

51. What is meant by a magnet being super-saturated?

A magnet is said to be super-saturated when it has received more magnetism than it can retain for any length of time after it has been magnetized.



Magnetic field around a pair of magnets, the north and south poles facing each other, like poles repel.

52. What is implied by the term Magnetic Flux?

The total number of lines of force flowing through a magnetic circuit.

53. What is the keeper of a magnet?

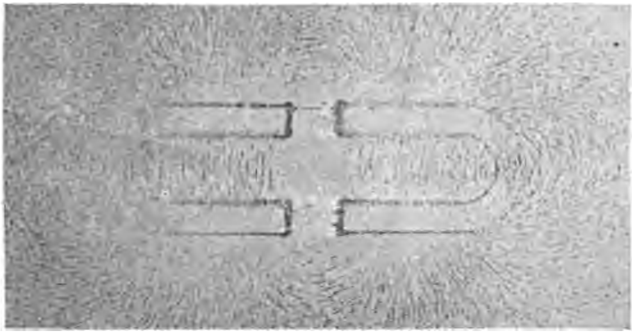
A piece of soft iron placed across the poles of a magnet through which the lines of magnetic force pass.

54. What is magnetic lag?

The inability of a magnet core to instantly lose its magnetism.

55. What is magnetic leakage?

A useless dissipation of the lines of magnetic force which fail to pass through an armature or winding.



Magnetic field around a pair of magnets, the north poles facing the south poles, unlike poles attract.

56. Define the power of magnetic induction?

It is the power which a magnet possesses to develop magnetism in iron. If a piece of soft iron be brought near a magnet, it immediately assumes the magnetic state, which however it loses on being removed from the magnetic influence.

57. What is meant by the term Magnetic Attraction?

The attracting power of a magnet when a piece

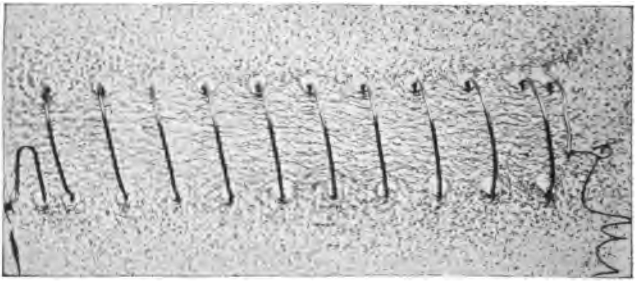
of iron is brought within the lines of magnetic force of a magnet.

58. What is meant by the term Magnetic Traction?

The force by which a keeper is kept in contact with a magnet.

59. What are Magnetic Poles?

Those members of a magnetic scource at which the flux enters or leaves.



Helix of wire traversed by an electric current, a magnetic field is created within the helix and the lines of force circulate around each turn of wire.

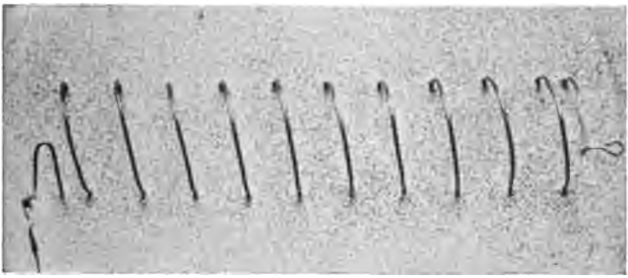
60. What are the pole pieces of a magneto?

Pieces of iron placed inside of the permanent magnets to define and limit the magnetic field.

61. How would you determine the North pole of a magnet, if it was not marked or a compass was unavailable?

The north pole of a magnet can be found by means of an ordinary needle, mark one of the

magnet poles and rub the point of the needle on the marked pole, rub the eye of the needle on the other magnet pole, suspend the needle from a light thread or float it on a disc of cork in a glass of water, the needle will then point north. If the sharp end of the needle points north then the marked pole of the magnet is of south polarity and if the sharp end of the needle points south, the marked pole of the magnet is of north polarity.



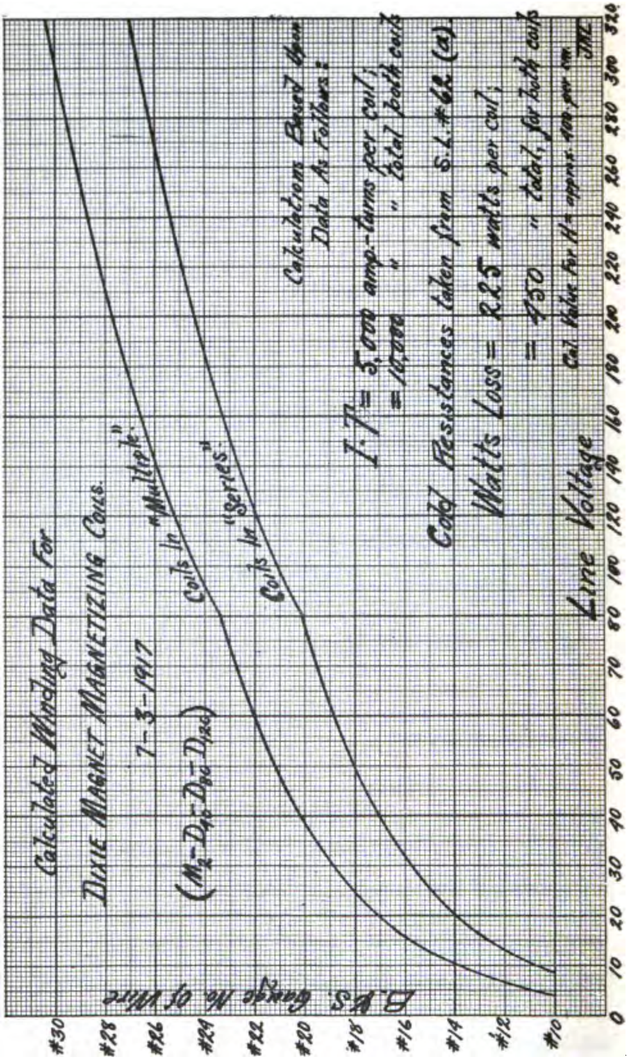
Helix of wire, note the absence of magnetic lines of force when no current is passing through the helix.

62. How would you determine the north pole of an electro-magnet?

If a bar of iron with a coil of wire on it is held before the dial of a clock, with one end of the bar pointing toward the dial, and the current flowing through the wire in the direction of rotation of the hands of the clock, then the lines of magnetic force will flow through the bar toward the clock. The north pole will be next to the clock.

63. What is an electro-magnet?

A magnet produced by the flow of a direct cur-



Formula for the calculation of magnetizing coils.

rent through a coil of insulated wire surrounding an iron core.

64. How would you describe a magnetic compass?

A magnetic needle, resting upon a pivot, enclosed in a circular case, the needle points nearly north.

65. What kind of current is used to magnetize magnets?

Direct current can only be used for this purpose.

66. What methods are used to magnetize permanent magnets?

Magnetization may be effected by magnetic induction from another magnet, usually a powerful electro-magnet, or by induction with a set of magnetizing coils traversed by a direct electric current which is the best method.

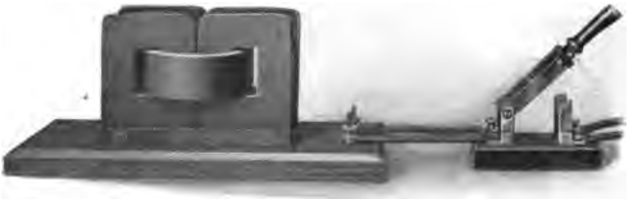
66-A How would you determine the proper way to insert a magnet in a magnetizing coil?

By determining the north pole of the magnet by a compass and marking it, next find the polarity of the magnetzing coils by inserting a piece of iron in it and switching on the current and find the polarity of the magnetized iron with a compass, then place the magnet in the coils to magnetize it in the same way that it was originally magnetized.

67. What means are used to magnetize magnets by the coil method?

Magnets are magnetized by inserting the poles in a set of coils wound to give the maximum mag-

netizing effect. The coils are usually wound with a certain size of wire, depending on the charging current, that is, depending on the line voltage and rating per coil, they may be connected in series or multiple. The accompanying tables give the relative size of wire necessary for the line voltage available, the resistance and number of feet of copper wire per lb. Consulting one of the tables it will be found that a set of coils absorb 450 watts and to wind a set of coils for use on a 110 volt line, No. 21 copper



Magnetizing coils, magnet in position to be magnetized.

wire should be used, the coils drawing 450 ÷ 110 or a little over 4 amperes. The resistance of the coils equals 110 ÷ 4 or 27.5 ohms, consequently as per table of copper wire, 2200 feet will be required and it follows that inasmuch as 5000 ampere turns are necessary for each coil, or 1220 turns of No. 21 copper wire. Similarily a set of coils wound for a 10 volt line would draw 45 amperes, each coil requiring 111 turns of No. 10 wire, or 110 feet. It must be borne in mind that the flow of current to fully magnetize a magnet is only a few seconds.

Table showing resistance and feet per pound of copper wire.

Brown & Sharpe wire gauge No.	Feet per lb.	Ohms per 1000 ft. 68° F.
10	32	1.
11	40	1.2607
12	51	1.5898
13	64	1.995
14	81	2.504
15	102	3.172
16	129	4.001
17	162	5.04
18	204	6.36
19	264	8.25
20	325	10.12
21	400	12.76
22	517	16.25
23	660	20.30
24	823	25.60
25	1029	32.20
26	1310	40.70
27	1650	51.30
28	2082	64.80
29	2623	81.60
30	3311	103.

68. How are magnetizing coils connected and wired?

Coils must be connected together to produce opposite poles when a magnet is inserted in them, a knife switch that is fused is usually placed between the charging circuit and the coils. Each coil has two leads which may be connected in series, that is, in series the current flows from the charging circuit through one coil, through the other coil back to the charging circuit, or the coils may be connected in multiple, that is, one of the leads from each coil are connected together, the combined leads are then connected to the charging circuit, the advantage of

the latter is apparent, as when a pair of coils are wound to be used in series with a 220 volt circuit, they may be connected in multiple for use with a 110 volt circuit.

69. What is an Ampere turn?

One turn of a winding through which a current of one ampere is flowing. The number of amperes multiplied by the number of turns in a winding equal the total number of ampere turns in a winding.

70. What is an ampere turn as applied to a winding?

The equivalent of one ampere passing through one turn of copper wire surrounding an iron core, that is one ampere carried around the core for 100 turns (100 ampere turns) will equal in effect ten amperes flowing through ten turns. The effect of the turns decreases with their distance from the core, a good rule to follow is, to wind the wire one inch deep on a core of one inch in diameter, or a total thickness of three inches.

70-A. How can the strength of a pair of magnets be retained when they are removed from a magneto?

The magnetic flux which flows from the north pole to the south pole will cause a pair of magnets of unlike poles to stick together, hence the rule, like poles repel and unlike poles attract, therefore when a pair of magnets are removed from a magneto they should at once be placed in a position

that there is a good metallic contact between the unlike poles.

70-B. Why is an iron core used in a winding?

An iron core inside of a winding increases the inductive effect, as a given current can produce more lines of force in an iron core than in air.

71. What is electrical induction?

It is the influence of an electrified body over other bodies.

71-A. What is called the primary current in a high-tension magneto?

The primary current flows through the primary winding of the magneto and usually consists of a few layers of coarse wire, it is wound next to the core.

71-B. What is called the secondary current in a high-tension magneto?

The secondary or high-tension current flows through the great number of turns of fine wire wound over the primary winding at the time of the passing of the spark between the electrodes of the spark plug, the high-tension current is induced in the secondary winding through the action of the circuit breaker interrupting the flow of primary current.

72. What is the effect of the secondary current on the iron core?

The secondary current retards the demagnetization of the iron core.

73. How does the duration of the secondary spark affect the iron core?

The duration of the secondary spark is inversely proportional to the length of the spark, the maximum value of the primary current being constant. This duration explains the relative slowness of the demagnetization of the iron core.

74. How does the lag in a winding vary?

The amount of lag varies with the co-efficient of self-induction, the capacity and the current value.

75. What are laminae and why are they used?

Structural subdivisions of the cores of armatures, elctro-magnets, etc., to prevent the loss of energy from eddy currents.

76. What are Eddy Currents?

Currents generated in a magnetized body by the variations of the strength of electric currents flowing near them, they are of no value however.

77. What is residual magnetism?

Magnetism remaining in the core of a winding after the magnetizing effect has ceased on the opening of the magnetizing circuit.

78. What is hysterisis and its effect on an iron core?

Hysterisis is the energy lost in the magnetizing and de-magnetizing of iron. An iron core magnetizes more rapidly than it de-magnetizes, a certain amount of residual magnetism always remains and hysterisis is due to the retention of energy. Hysterisis manifests itself in the form of heat, but must not be confounded with eddy currents which are avoided by sub-dividing the iron core, whereas hysterisis depends upon the quality of iron and length of the core.

79. What is the ratio of the primary to the secondary winding?

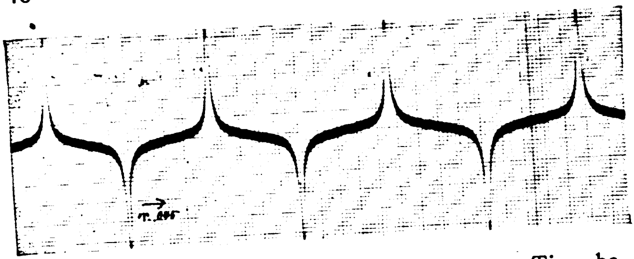
The ratio of primary to the secondary winding is approximately 60—1 or 200 turns of primary wire to 12,000 turns of secondary winding.

80. What is the size of wire on the primary?

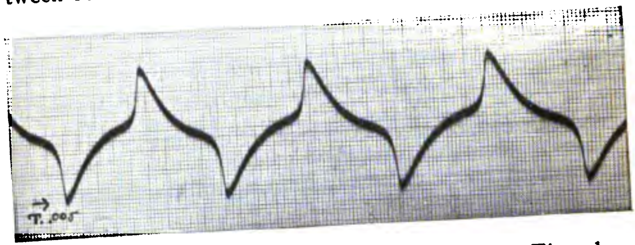
The size of wire on the primary varies from No. 19—24 B&S gauge and is usually enameled, silk-covered or both.

81. What is the size of the wire on the secondary?

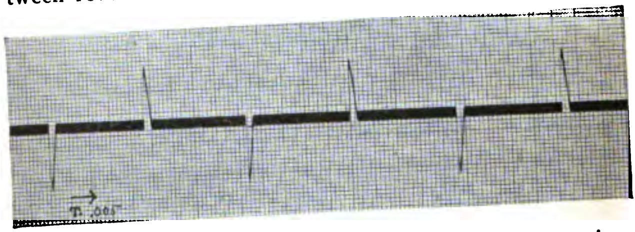
The size of wire on the secondary varies from No. 34—38 B&S gauge, enameled wire is usually employed, this insulation does not occupy much space, permitting the winding to lay nearer to the core to obtain the maximum secondary effect.



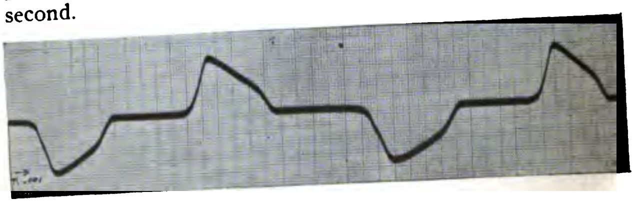
Primary voltage, H armature type magneto. Time between reversals .125 second.



Primary current, H armature type magneto. Time between reversals .125 second.



Secondary current over a .031 spark gap of high tension H armature type magneto. Time between sparks .125 second.



Primary current, H armature type adjustable pole magneto. Time between reversals .055 second.

Oscillograph diagrams.

82. What is a coil employing the principle of the extra current called and how is it used?

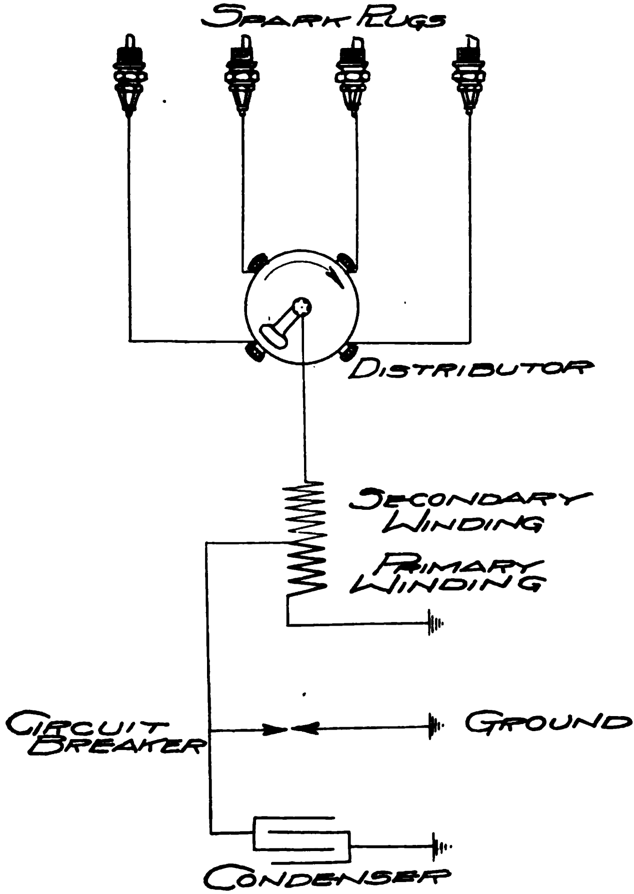
A reactance coil for low-tension ignition is composed of an iron core and a number of layers of copper wire. Due to the inductive action of the coil, when the current is interrupted by the action of the igniter which causes the current to flow longer in both time and distance across the gap formed by the separation of the igniter contacts within the cylinder. A reactance coil becomes necessary when a battery is used to supply the current, whereas when a low-tension magneto is used, the inductive action of the armature acts in the same manner.

83. What are Oscillograph Diagrams?

Oscillograph diagrams show in a graphic way just what occurs in both the primary and secondary windings. When the primary circuit is closed, the current rises gradually in value, until the circuit is broken, no current will be induced in the secondary circuit during the period the primary current is attaining its full value, which is due to the fact that the electro-motive force induced in the secondary winding during this period is not sufficiently great to break down the resistance of the air gap at the spark plug. The spark occurs when the primary circuit is broken, rising to its maximum value instantly.

The oscillograph diagrams show that both the electro-motive force and the current of a magneto rise to a sharp peak, first in one direction, then in the reverse direction, as the current is an alternating one.

It will be noticed that only the peak of the current wave is utilized for the production of the secondary current, the maximum current value be-



Internal circuit diagram, high-tension magneto.

ing reached when the greatest number of magnetic lines of force in the permanent field of a magneto are cut.

84. What is a condenser?

A condenser is a device for increasing the capacity of an insulated conductor by bringing it near another insulated earth-connected conductor, but separated from it by a medium that will permit electro-static induction to take place through its mass.

85. What is the function of a condenser?

The function of a condenser is to absorb the initial rush of current when the platinum contact points of a circuit breaker are separated, otherwise destructive arcing would occur, this prevents the rapid rupture of the primary current, with a consequent decrease of the induction in the secondary winding.

86. How is a condenser constructed?

A condenser consists of a number of sheets of tin-foil, separated by a dielectric of very thin sheets of mica or a special grade of paper. Each alternate sheet of tin-foil extends beyond the edge of the insulating material, these are pressed together so as to make electrical connection between them and form one side of the condenser, the sheets of tin-foil projecting from the opposite side are also pressed together, forming the other side of the condenser. The finished condenser is usually impregnated with a varnish or other insulating compound and pressed to exclude moisture.

87. What is meant by the dielectric in a condenser?

The insulating medium of a condenser which separates the sheets of tin-foil and permits induction to take place through its mass.

88. What part of a condenser retains the charge?

The charge of a condenser remains on the opposite surfaces of the dielectric separating the tin-foil.

Cross section, spark plug, rotary engine type.

89. What is meant by a condenser discharge?

The equalization of the difference of potential from its maximum to zero, when the terminals of a condenser are connected by a conductor.

89-A What is the action of the condenser on the primary winding after the contact points have separated?

The charge impressed upon the condenser by absorbing the extra current at the contact points in the moment of the opening of the primary circuit is

returned to the primary winding when the contacts come together in the form of a current of about 40 volts and ½ milli-ampere.

90. How is the capacity of a condenser measured?

The capacity of a condenser is measured in micro-farads.

91. How can you test a condenser, also ascertain if it holds its charge or leaks?

By comparing it with a standard condenser. Connect the condenser to be tested in series with a milli-ammeter and place the terminals of a test line on one of the terminals of the condenser and the other on one of the terminals of the meter, the deflection of the meter depends upon the condition of the condenser, the more the deflection, the less the charge, as a greater deflection than shown by a standard condenser denotes a leak which permits the current to flow through the condenser. The milli-ammeter should be one of a low range or reading, with the pointer in the center, the scale calibrated to read 5-0-5 milli-amperes. When charging the condenser, the pointer will be deflected to one side of the scale, on discharge the pointer will be deflected to the other side of the scale on the meter.

92. What is a micro-farad?

A micro-farad is the millionth of a farad. A condenser of a capacity of one micro-farad will contain about 3600 square inches of tin-foil. Con-

densers for ignition apparatus are usually rated from .25 to .6 of a micro-farad capacity.

93. What is the effect of too large a condenser in a magneto?

Too large a condenser lowers the secondary electro-motive force.

94. What is the effect of too small a condenser?

A condenser of low capacity results in destructive arcing at the contact points and a poor spark at the secondary terminal.

95. What is a spark?

The luminous path produced by the incandescence of the air broken down by the discharge. The space is afterwards filled with metallic vapors, given off by the sparking electrodes.

96. What is necessary to produce a spark?

In order that a spark can pass between two electrodes that are separated from each other, there must exist a difference of electrical potential or striking voltage, the value of which depends upon the width of the spark gap, the form of the sparking electrodes, the nature and condition of the medium in which the spark passes.

97. What is a Spark plug?

A spark plug is a spark gap placed within the cylinder of an internal combustion engine.

97-A. What is meant by a difference in potential?

This is a term usually employed to denote the voltage of the secondary current that exists between any two points of the circuit.

98. What are the parts of a spark plug?

A metal shell having a threaded end that screws into the cylinder, a core which must be a good insulator and heat resisting is fitted pressure tight within the metal shell, a metal rod through the center of the core is fitted with a sparking electrode at the end projecting into the cylinder, and a terminal at the outer end to which the spark plug lead is attached. The spark passes between the center electrode and another electrode in the shell, or the spark may pass between the center electrode and the shell itself.

99. How is the secondary capacity of a high-tension current distributed?

The secondary capacity is not situated at the electrodes of a spark plug, it is distributed in a more or less regular manner throughout the entire secondary circuit.

100. What are electrodes?

The terminals of an electrical source, such as the electrodes of a spark plug.

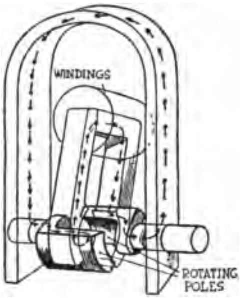
101. How should the gaps between the spark plug electrodes be set?

The setting of the spark plug electrodes is an

important function and it is advisable to set the gaps all alike, otherwise the engine will not run evenly, the width of the gap may vary under different circumstances, but a setting of .025 or 1/40th of an inch has been found to be good practice.

102. Why are the gaps of spark plug electrodes set close?

Although there is but a short distance between the electrodes of a spark plug, the spark encounters a certain resistance in overcoming the gap, because of the compression of the mixture. The equivalent



Magnetic flux path of a polar inductor magneto.

spark at atmospheric pressure may be twelve times longer than the spark under compression, which may be verified by placing a spark gap in shunt with the spark plug.

103. What is the effect of too close a gap of the spark plug electrodes?

Spark plug gaps that are set too close tend to heat the electrodes causing preignition and poor inflammation of the mixture.

104. What is the effect of too wide a gap of the spark plug electrodes?

Gaps that are too wide will cause the engine to miss when the throttle is opened suddenly, also cause the magneto to spark at the safety gap.

105. What are the usual causes of failure of a spark plug?

Short-circuited from carbon, cracked porcelains, electrodes burnt away, not pressure tight, moisture condensing on the insulator.

106. What is implied by the term brush discharge and how does it occur?

It is an electrical phenomenon which may be observed in the dark in the form of a luminous silent discharge which occurs at the high-tension cables and sometimes the spark plugs. It is due to the nature of the high-tension current, a leakage occurring into the air. The ignition, however, is not affected by it.

107. How would you locate a defective spark plug cable?

By observing the leakage of the high-tension current in the dark or the failure of the high-tension current to reach the spark plug.

108. What is a storage battery?

Two inert plates immersed in a liquid incapable of acting chemically on either of the plates until after the passage of an electric current, when they

become capable of furnishing an independent electric current. A storage battery, so called does not store electricity, any more than a spring of a clock can be said to store time or sound. The spring stores muscular energy, that is, renders the muscular kinetic energy, potential, which again becoming kinetic, causes the works of a clock to move and strike. In the same way in a so-called storage battery, the energy of an electric current is caused to produce electrolytic decompositions of such a nature as to independently produce a current on the removal of the electrolizing current.—(*Houston.*)

109. What is the principle of a storage battery?

A storage battery does not actually store electricity, nor does it make electricity, it is simply a reservoir. The term; charging a battery by the use of an electric current brings about a chemical change, which in turn will produce electricity when the circuit is completed.

110. How would you describe the construction of a storage battery?

A storage battery is composed of two sets of plates separated from each other by strips of wood called separators. Alternate plates are fastened together, one group at one of the upper corners, the other group at the opposite diagonal corner. The two groups of plates are designated, respectively, as negative and positive. There is usually one more plate in the negative group. The negative plates are filled with spongy lead and the positive plates with lead peroxide. The two groups

of plates are placed in a jar made of hard rubber, commonly called a cell, the plates rest on a pair of ribs to allow any of the active material which may drop from the plates to collect in the bottom of the cell without causing an internal short circuit. The plates after being placed in the cells are entirely covered with a solution of chemically pure sulphuric acid and distilled water, this solution has a specific gravity of 1.275—1.300 Baume scale, when the battery is fully charged. This solution is called the electrolyte, the electrolyte of a fully charged storage battery is therefore a solution of two parts concentrated sulphuric acid and three parts water.

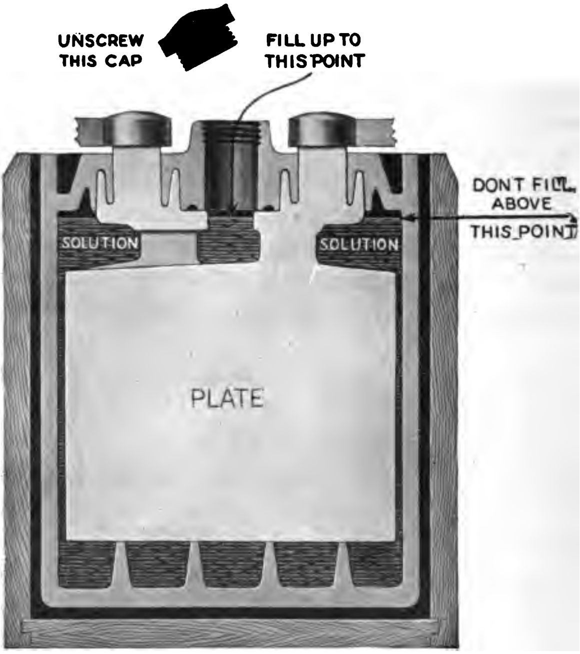
111. What happens within a storage battery when it is discharging?

When a storage battery is discharging, the sulphuric trioxide of the sulphuric acid unites with the active material in both sets of plates, forming lead sulphate on the plates and leaving water in the solution, thus diluting it and raising the proportion of water to acid. For this reason a storage battery should be recharged at once after being discharged, as the forming of lead sulphate on the plates will eventually ruin the battery.

112. What happens within a storage battery when it is being charged?

When the storage battery is charged by sending a direct current of electricity through it in the opposite direction from which it was delivered from the battery, a reverse action takes place. The sulphuric trioxide leaves the plates, thus doing

away with the lead sulphate which unites with the water in the solution, forming sulphuric acid and increasing the specific gravity of the electrolyte.



Section of a storage battery of the lead plate type.

113. How is the capacity of a storage battery rated?

The amount of current a storage battery will store or discharge depends upon the area of the plates contained within it, and usually measured in ampere hours. Thus a battery of ten amperes for ten hours or five amperes for twenty hours or one ampere for one hundred hours is said to have a capacity of one hundred ampere hours.

114. Why is it necessary to add water to the electrolyte in a storage battery?

Pure distilled water only should be added to the electrolyte in a storage battery, covering the plates to a depth of 1/8 of an inch, to make up for the loss of evaporation, otherwise the capacity of the battery will suffer and the exposed plates become sulphated, eventually ruining the battery.

115. What is the electro-motive force or voltage of a storage battery?

When a storage battery is freshly charged, each cell will be found to have an E.M.F. of about 2.25 to 2.50 volts, but after being used a short time this falls to about 2 volts, at this figure it remains until the cell is nearly exhausted. This applies to the lead plate type of storage battery.

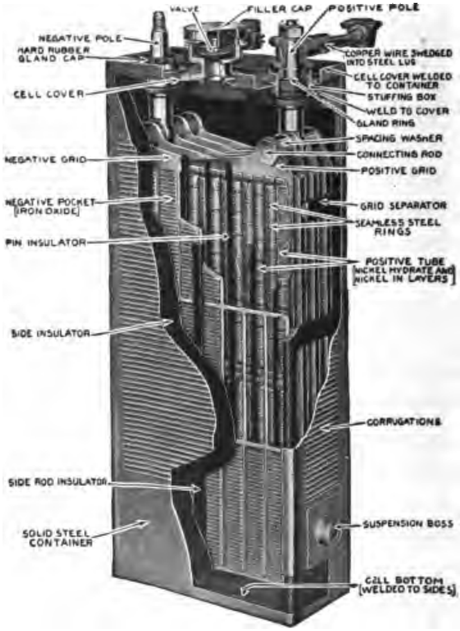
116. What is an Edison storage battery and how does it differ from the lead type battery?

This battery embodies a construction which employs an entirely different combination of elements from that used in the lead-acid types. The active materials are nickel hydrate and iron oxide and the electrolyte or liquid which surrounds the elements is an alkaline solution of potassium. The positive plate consists of perforated cylindrical steel tubes containing nickel hydrate and pure metallic nickel flake. The negative plate consists of perforated flat steel pockets contaning iron oxide.

117. What is the electro-motive force of an Edison Storage Battery?

At the beginning of discharge there is a peak

voltage of short duration which may be anywhere from 1.3 to 1.5 volts depending upon the period elapsing between charge and discharge. Practically the maximum voltage during a normal rate discharge is about 1.3 volts per cell. Open circuit voltage



Section of a storage battery of the Nickel-Iron type.

is variable and has no useful significance in storage battery practice. The Edison Storage Battery will maintain an average voltage of 1.2 volts during its discharge. When the voltage drops to 1 volt the battery may be considered discharged.

118. How is the density of the electrolyte in a storage battery tested?

It is tested by means of a hydrometer which is graduated to read the density (specific gravity) on a scale on the stem of the hydrometer. The hydrometer is usually enclosed in a glass tube which holds a portion of the liquid withdrawn from cell to be tested, the lower end of the glass tube is fitted with a rubber tube long enough to reach the liquid in the cell through the filler cap, the upper end of the glass tube is fitted with a bulb syringe. When enough of the liquid is withdrawn from a cell to float the hydrometer a reading can be taken at the stem of the hydrometer, rising above the level of the liquid within the tube.

119. What is specific gravity?

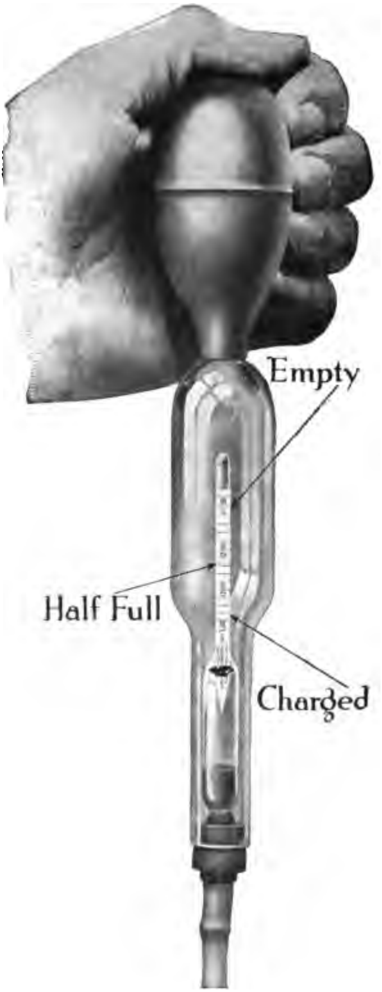
Specific gravity is the weight of a substance compared with the weight of the same bulk of another substance. Water is taken as the standard for liquids.

120. What is meant by the term, Leads?

The insulated conductors which lead to and from a source of electricity, such as the leads of a storage battery.

121. What is meant by Sulphating in a Storage Battery?

The formation of a hard white basic sulphate on the plates of a storage battery, due to the battery remaining in a discharged condition.



Hydrometer syringe, the hydrometer will float in the electrolyte of a lead plate storage battery when it is in a discharged, half charged or charged state as indicated.

122. What is meant by Buckling of the plates in a storage battery?

The warping in storage battery plates due to a too rapid discharge.

123. What methods are used to find the polarity of a Storage Battery or charging circuit?

Dip the leads from a storage battery or charging circuit in a glass of water with a little salt in it, bubbles will appear at the negative pole.

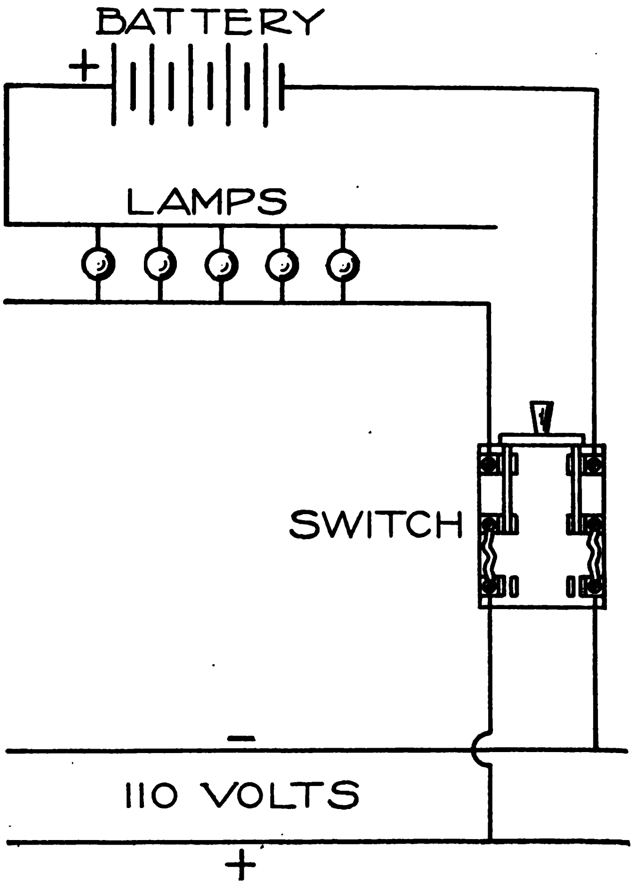
Connect the leads of a storage battery to copper wires and hold them on a slice of raw potato about a quarter of an inch apart, the positive pole will turn green.

A polarity indicator connected in the circuit of a storage battery will show red at the negative pole.

Procure some blue litmus paper from a drug store, moisten the same, place the two leads of a storage battery on the moisted paper about a quarter inch apart, the positive pole will turn the litmus paper red.

124. What is a battery charging circuit?

In a battery charging circuit a source of direct current is usually connected to a fused double-throw switch, one of the switch leads going to a bank of lamps connected in multiple, the other lead from the lamps connecting to one of the terminals of the storage battery and the other terminal connected to the knife switch. On a 110 volt line the battery will charge approximately at the



Wiring plan of a storage battery charging circuit.

rate of 1 ampere per hour for every 32 C.P. carbon lamp or ½ ampere if 16 C.P. carbon lamps are used. The positive lead of the charging circuit must be connected to the positive terminal of the battery.

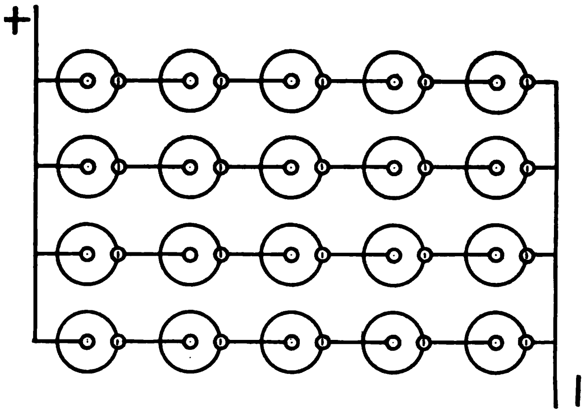
125. How should a storage battery be properly connected to a charging circuit, when the polarity of neither the charging circuit or the storage battery are known?

If the leads of a charging circuit having a lamp in series with it are connected to a storage battery, first one way, then in the reverse way, it will be noticed that there is a difference in the brightness of the lamp. The battery is connected properly whichever way the lamp glows dim.

126. How is a dry cell constructed?

A dry cell comprises a container of zinc which forms one of the electrodes, the zinc container is lined with absorbent or blotting paper, this is saturated with a solution containing zinc chloride and sal-ammoniac. In the center there is a carbon rod or plate around which is packed a mixture of, maganese dioxide (Mn 02) and powdered carbon. The carbon electrode is usually capped with a brass piece terminating in a binding post, another binding post is soldered to the top of the zinc container. The binding post on the carbon is the positive and the binding post on the zinc is the negative terminal. The action of the cell is as follows; the manganese dioxide is a depolarizer, it gives up oxygen, this combines with the hydrogen gas which is liberated by the

chemical action within the cell. The hydrogen and oxygen combine to form water, which remains in the cell and furnishes the moisture necessary for the continuous generating of current.



Dry batteries connected in multiple-series.

127. How should a set of dry batteries be connected to insure long life and service?

A dry cell is usually rated at 1.25 volts and .25 ampere. To obtain the best results, a set of dry batteries should be connected in multiple-series, for example, a circuit requiring 6 volts and 1 ampere, 20 cells should be used, connect 5 cells in series, that is, the positive terminal of one cell is connected to the negative terminal of the next cell until 5 cells are connected in series, leaving a positive and negative terminal open, then connect 4 such sets in

multiple, that is, all of the positive terminals of each series are connected to one lead, and all of the negative terminal to another lead as per diagram.

128. What is Electromotive Force?

The force that causes electricity to move. Usually abreviated E. M. F.

129. What is the estimated velocity of the electric current?

It has been estimated that the velocity of electricity through a copper wire is 288,000 miles per second.

130. What is the difference between static and voltaic electricity?

Static electricity is sudden, noisy and convulsive, voltaic electricity is silent, constant and powerful.

131. What is an Ampere?

The practical unit of the rate of flow of electric current.

132. What is an ampere Hour?

Amperes of current flowing in an electrical circuit multiplied by time in hours, equals ampere hours.

133. What is a Milli-ampere?

The 1000th part of an ampere.

134. What is an alternating current?

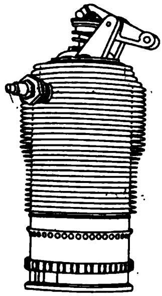
An electric current which flows alternately in opposite directions.

135. What is direct current?

An electric current flowing in one direction.

136. What is meant by the term, Positive pole?

In a magnetic circuit, the north pole from which the lines of force emerge into the air. In an electrical circuit, the pole from which the current flows into a circuit.



Cylinder, rotary engine.

137. What is meant by the term, Negative pole?

In a magnetic circuit, the negative pole into which the lines of force flow. In an electrical circuit, the pole into which the current flows after having passed through the circuit connected to the source.

138. What is an electrical conductor?

A conductor is a body or substance which allows the electric force to pass freely through it.

139. What is an insulator?

An insulator is a non-conductor, offering considerable resistance to the flow of the electric current. Rubber is one of the best insulators.

139-A What is called insulation?

A non-conducting covering, to prevent the leakage of the current in any metallic substance.

140. What is Resistance?

That property of an electrical conductor by which it opposes the flow of an electrical current.

141. What is the unit of electrical resistance?

The unit of electrical resistance is called an ohm, it is the amount of resistance that will limit the flow of an electro-motive force of one volt to a current of one ampere in an electrical circuit.

142. What is Ohms law and how is it applied?

$$I = \frac{E}{R}$$

The current in amperes is equal to the electromotive force in volts, divided by the resistance in ohms.

$$E = I \times R$$

The electro motive force in volts, is equal to the product of the current in amperes and the resistance in ohms.

$$R = \frac{E}{I}$$

The resistance in ohms is equal to the electromotive force in volts, divided by the current in amperes

143. What is a Rheostat?

A rheostat is a device for the purpose of varying the resistance of an electrical circuit.

144. What is an open circuit?

An open circuit exists when a continuous electrical circuit is broken, preventing the flow of current through it.

145. What is a closed circuit?

An electrical circuit is closed when a conducting continuous path is established that a current can pass.

146. What is a short circuit?

A shunt path of low resistance around any portion of a circuit, which prevents the flow of current through the main circuit.

146-A. What is meant by the term ground circuit?

The term applied to the return circuit of the primary and secondary windings of a magneto, when the current flows through some metallic part of the magneto, other than an insulated conductor.

147. What is an electrical capacity?

The ability of a conductor to permit a certain quantity of current to be passed into it before acquiring a difference in potential.

148. What is meant by dampening?

The act of bringing the pointer of an electric measuring instrument to rest quickly.

149. What is a Switch?

A switch is a device for opening or closing an electrical circuit.

149-A. What is an ignition switch?

A switch with one wire leading to the ground terminal on the magneto, the other wire from the switch is grounded to some metallic part on the engine, when switch contacts are closed the primary current is grounded and the magneto becomes inoperative.

150. What are common causes of failure in a switch?

Loose or dirty contacts or poor connection at the terminals.

151. What is Platinum?

A refractory white metal which does not oxidize readily, the specific gravity of platinum is 21.53, which means that this metal is 21.53 times heavier than water.

152. What is a test line?

A test line consists of a connection to a 110 or 220 volt circuit, preferably direct current, one of

the line wires terminating in a flexible cable with a piece of 1/16th of an inch copper wire at the end for testing. The other line wire is connected to a lamp socket carrying a lamp, the other connection from the socket terminates in another flexible cable. When the ends of the two flexible leads are brought together, the circuit is completed and the lamp lights. The test line will be found useful for testing the continuity of windings, open or short circuits, condensers, etc.

Buzzer test set.

153. What is a buzzer test set?

A box containing two dry cells, on top of which is mounted an ordinary vibrating buzzer, the batteries in the box are connected in series, one of the battery leads terminating at a binding post on top of the box, the other battery lead connects to one

of the terminals of the buzzer, the other terminal from the buzzer is connected to another binding post on top of the box. A pair of flexible leads with spring clips at the ends are useful for testing circuits in ignition wiring, also for setting the magnetic break on magnetos, etc.

154. What is an induction coil or transformer as applied to ignition?

A coil wherein the electro-motive force of a portion of a circuit is by mutual induction made to cause a higher electro-motive force in a contiguous circuit such as the secondary winding.

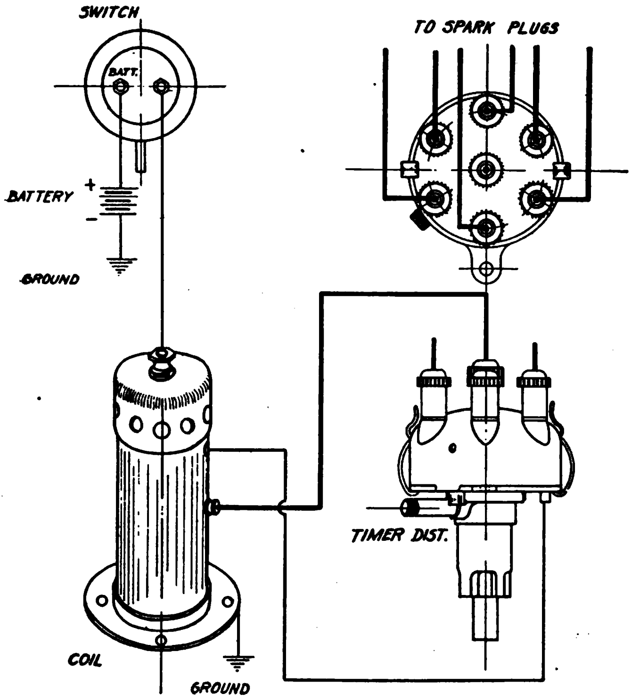
155. What are the units of a modern Battery-timer ignition system?

A combined timer-distributor, a transformer coil, a storage battery and a generator to keep the battery charged.

156. How does a Battery-timer system operate?

When in operation, the contact points—which in many cases are composed of tungsten—are first closed by the action of a spring for a certain period during which the primary grows in value, at the proper time the contact points are suddenly separated by the action of the cam. At that instant the high-tension spark occurs as a result of the enormous voltage induced in the secondary winding by the collapsing of the magnetic field created by the primary current. The intensity of the high-tension

spark is dependant—other things being equal—on the value of the primary current when the contact points are separated.



Typical battery-timer circuit.

The primary current flows from battery ground to battery, to switch, to ballast resistance, to primary winding, to circuit breaker, to ground.

The high-tension current flows from coil ground to secondary winding in coil, to distributor, to spark plug, to ground.

157. What are the principal parts of a typical Battery-timer ignition system?

A battery, a switch, a transformer or induction coil, a timer base upon which the circuit breaker and condenser are mounted, a shaft having a number of cam lobes equal to the number of cylinders to be fired, a distributor finger is usually mounted on top of the timer shaft, a cover which at the same time acts as a distributor completes the outfit.

158. What is the usual arrangement of the timer parts?

A plate on which the circuit breaker and condenser are mounted, a base which forms a bearing for the shaft which carries the cam and distributor finger, the whole being surmounted by the distributor. An extended arm is provided for the variation of the spark.

159. How are the windings of a Battery-timer connected?

The primary winding of the transformer is connected in series with the ballast resistance and the circuit breaker, a condenser is connected directly across the points of the circuit breaker. The secondary winding is grounded at one end and the other end leads to the rotating finger of the distributor.

160. What is the ballast resistance in a Battery-timer coil?

The small amount of resistance which is connected in series with the primary winding, this limits the amount of battery current flowing through the coil.

161. What is the action of the Ballast resistance?

When the timer coil operates under normal conditions, the ballast resistance does not affect the amount of current flowing through the primary winding, if the engine stops and the switch is not placed in the "off" position to cut off the flow of battery current, under this condition an increased amount of current flows through the primary circuit and the ballast resistance, with the result that the ballast resistance heats and offers a greater resistance this limits the amount of current flowing through the primary, preventing it from burning out from any excess of battery current and at the same time preventing a rapid discharge of the battery.

162. What is meant by battery-timer coil lag?

Between the instant of opening of the primary circuit and the occurrence of the spark at the spark plug, an interval of time elapses which is appreciable in comparison with the length of time required by one revolution of a high speed engine. A certain amount of time is required for the primary current to attain its full strength, this is called the magnetic lag of the coil. The time required for the timer contacts to open or close through the action of a spring also requires some time, this is called the mechanical lag of the circuit breaker.

163. What is the effect of lag in a battery-timer system?

In a battery-timer system the spark must be advanced because the spark does not take place

at the moment when the contact points open, there is a retarding influence that varies according to circumstances, that is one reason why a battery-timer requires more advance than a magneto.

163-A If the lag in a battery-timer system on an engine running at 2000 R.P.M. was equal to 1/30 of a revolution measured on the flywheel, how far must the timing lever be advanced to correct it?

30 divided by 360 equal 12, timer running at cam shaft speed, advance necessary 6 degrees.

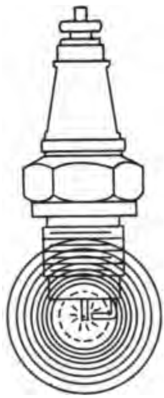
164. What is the difference between a timer coil and the winding of a high-tension magneto?

If the ballast resistance were eliminated so that the primary winding is short-circuited upon itself when the contacts are closed, the only vital difference between the working of the two systems is that, whereas, in the action of the magneto, the primary current is generated by magnetic induction and in a battery-timer system the current is supplied by a battery of practical constant voltage.

165. What is the principle of ignition of the mixture in an engine?

The principle of ignition of the mixture in an internal combustion engine may be defined as follows, to produce at a precise moment in the travel of the piston, a spark capable of igniting the mixture, the moment when the spark should take place varies with the engine and its speed.

The ignition of the mixture is not instantaneous, the spark first ignites the mixture immediately surrounding the electrodes of the spark plug, the propogation of the flame takes place at a speed o about 12 feet per second, so in order to obtain the maximum effect on the piston, the spark should take place at a given time before the passing of the crank over the top dead center.



Flame propagation around the electrodes of a spark plug.

166. What is the principle of compression in internal combustion engines?

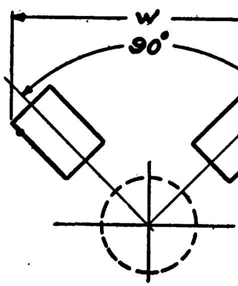
One of the fundamental principles of the internal combustion engine is the compression of the charge, of course the gas or mixture would explode at atmospheric pressure, but it was discovered long ago that the explosion was much stronger if compression took place before ignition.

When the mixture is compressed to half of its original volume the pressure is doubled, when the piston begins to return on the compression stroke the inlet valve closes, forcing the mixture into a smaller space, one quarter of its original volume as a rule. Then, when ignited, it explodes with far greater force than otherwise could be possible, in this way by using a smaller engine cylinder and less combustible mixture, higher efficiency is obtained. When an engine runs at high speed, the mixture cannot enter fast enough to fill the cylinder before the inlet valve closes, and for this reason some engines have more than one inlet valve or the inlet valve is not closed until the piston has passed the lower dead center.

As a rule the mixture has to rush through the carburetor and along the induction pipe and finally through the inlet valve and several short turns. On occasions the speed of the mixture is apt to be more than 1000 linear feet per minute, but owing to friction a full charge of gas is unable to enter the cylinder in the very short period the inlet valve is open, so the compression suffers, the same thing happens when the engine is very hot, as the high temperature rarifies the charge, making it less powerful, and consequently great care is taken to design the induction passage correctly in order that full compression and the greatest efficiency may be obtained. High compression also has its effect on the ignition which manifests itself in that sufficient spark may be obtained from the ignition system under normal compression, but when the compression is exceedingly high, the spark is apt to take the safety gap or fail altogether.

167. How would you define the term Cycle as applied to the internal combustion engines?

A series that repeats itself, a recurring series of operations, as in internal combustion engines in which heat is imparted or taken from a substance, which by expansion gives out energy, and is finally returned to its original condition.



Angularity of the cylinders of a 90 degree Vee type engine.

168. What is meant by a cycle as applied to the internal combustion engine?

The four strokes necessary for one operation.

169. Name in detail the operation of the four stroke cycle internal combustion engine?

With the intake valve open the piston descends and draws in the mixture on the suction stroke, then the piston rises, with the valves closed, compressing the mixture on the compression stroke. When the piston passes over dead center the spark occurs, exploding the compressed mixture and the

piston is driven down with the valves still closed, on the power stroke. The piston again ascends, forcing the spent gases out through the open exhaust valve, completing the four stroke cycle with the exhaust stroke.

170. What is a carburetor?

A mechanical device for mixing gasoline and air in proper proportions.

171. What are the principal parts of a carburetor?

Float chamber, spray nozzle, air intake and throttle.

172. What are the indications of too rich a mixture?

Black smoke issuing from the exhaust.

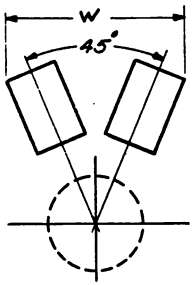
173. What are the indications of too lean a mixture?

Popping back into the carburetor.

174. How is the term horse power defined?

Horse power is a term employed to measure power, which is the product of force, acting through a certain distance of space and a certain length of time. 1 horse power is equivalent to the force required to lift 33000 lbs. 1 foot high in 1 minute. It is the standard of measurements in which all the elements of force, space and time enter. Horse power as applied to the gasoline engine may be

termed, brake or rated. Actual or brake horse power is usually determined by the use of the dynamometer, which is a means of converting the power developed by a gasoline engine into elecricity, the amount of electricity generated is measured in volts and ampers, which, when multiplied together are called watts, 746 watts equal 1 horse power, therefore the number of watts, divided by 746 would



Angularity of the cylinders in a 45 degree Vee type engine.

represent the horse power developed by the gasoline engine under test. Rated horse power is determined by a means of a formula devised by the Society of Automotive Engineers. This formula is expressed as follows, D^2 multiplied by N, divided by 2.5 equals horse power. In this formula D equals the bore of the cylinders in inches squared, and N the number of cylinders divided by the constant 2.5.

$$D^2 \times N = H.P.$$

This formula, however, is subject to modifications, as neither the factors of piston speed or the mean effective pressure are compensated for.

It requires 1 horse power to lift 33000 lbs. 1 foot high in 1 minute, or 550 lbs. 1 foot high in 1 second or 330 lbs., 100 feet high in 1 minute.

175. How can brake horse power be calculated by formula?

$$\frac{D^2 \times \frac{Pi}{4} \times S \times N}{7500} \times R.P.M.$$

D^2 = Diameter of piston, in inches squared.

$\frac{Pi}{4}$ = ¼ of Pi or .7854.

S = Lenth of stroke in inches.

N = Number of cylinders.

7500 = Constant.

R.P.M. = Revolutions per minute.

176. Why is it necessary to time the magneto to the engine?

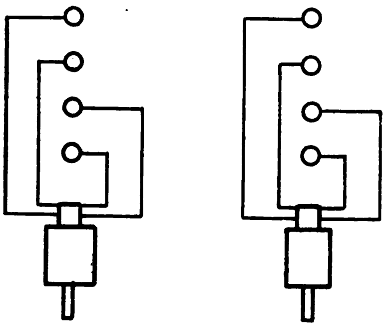
To have the spark occur at the proper moment.

177. How would you proceed to time a magneto to an engine?

One of the cylinders is usually designated as No. 1.* In an engine with the cylinders in line, the cylinder nearest to the starting crank and in airplane engines the left hand cylinders nearest to the pump are designated as No. 1.

*NOTE—No standard designation of No. 1 cylinder having been adopted by Airplane engine manufacturers, all firing diagrams show No. 1 cylinder at the left side, pump end.

Place the piston of No. 1 cylinder on the upper dead center (or follow the manufacturers instructions), place the magneto on its base with the coupling loose, place the timing lever in the full retarded position, or, if the magneto is of the fixed spark type it must be set a number of degrees later when timing in order to prevent any back-kick from the engine.



Magneto ignition system, 8 cylinder Vee engine, the units comprise two high-tension magnetos, firing one spark plug in each cylinder on separate engine blocks.

Remove the breaker cover and turn the magneto shaft in the direction in which it is to rotate until the platinum points of the circuit breaker are about to separate, in this position secure the coupling to the magneto shaft, taking care not to alter the position of the shaft.

Fasten the magneto to its base. Remove the distributor block and note which terminal of the distributor block is in contact with the distributor, connect cable leading from the spark plug of No. 1 cylinder to the terminal on the distributor block

which is in line with the distributor brush or segment and connect the remaining spark plug cables according to the sequence of firing and the rotation of the distributor. If the distributor block is marked set the brush or segment leading to No. 1 terminal on the block before securing the coupling to the magneto shaft.

178. What is meant by timing lever manipulation?

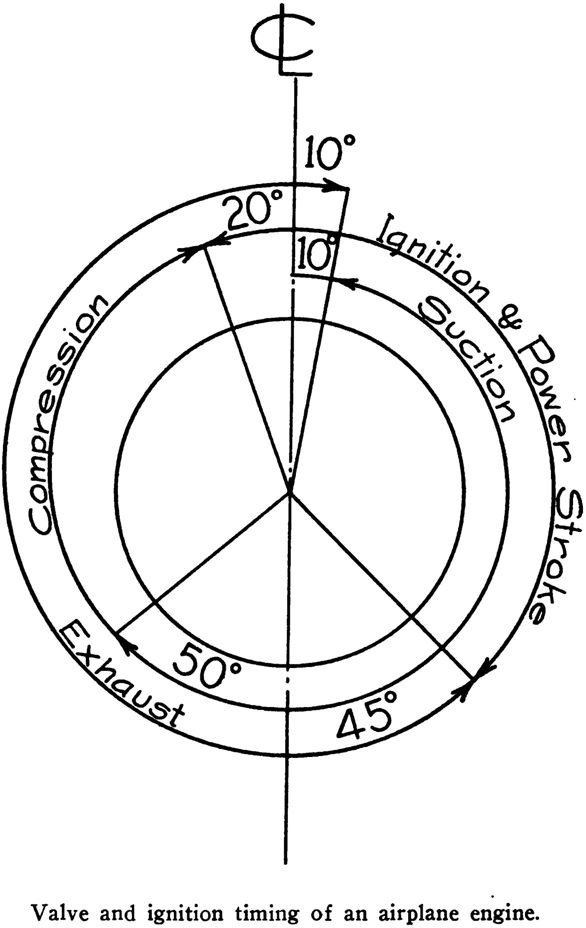
Varying the time of ignition is desirable for several reasons which may be due, either to lag of the ignition device, quality of the mixture, speed of the engine or conditions of load under which the engine is operated.

In a magneto a very brief period of time is required to complete a cycle of operation which consists of the reversal of polarity in the windings, building up and interrupting the current in the primary circuit and distributing the high-tension current to the spark plugs.

In a battery ignition system more time is required to build up the primary circuit, there may also be some mechanical lag in the interrupter, consequently more spark advance is necessary in a battery ignition system than when magneto ignition is employed.

A lean mixture is slow burning, more time being required for full inflamation, the same being true of too rich a mixture, in both cases the spark timing must be advanced.

The lag of the spark is proportional to the speed of the engine, at 2000 revolutions per minute, the crankshaft will move twice as far before the spark



Valve and ignition timing of an airplane engine.

Inlet valve opens—dead center.
Inlet valve closes—50 degrees late.
Ignition occurs—20 degrees ahead of dead center.
Exhaust valve opens—45 degrees from bottom dead center.
Exhaust valve closes—10 degrees after top dead center (Hispano-Suiza).

occurs than at 1000 revolutions per minute consequently an earlier spark timing is required.

The higher the piston speed the earlier in the stroke should the spark occur in order that the maximum pressure may be exerted at the most advantageous point. Consequently spark advance is needed because after the electrical circuit is broken and the spark has taken place in the combustion chamber, a short time interval elapses before the charge is fully ignited and sufficiently expanded to exert the maximum pressure on the piston.

The timing lever should be in a position in proportion to the load and a good operator learns to observe the effect of manipulating the timing lever and act accordingly, gauging the lever position for engine speed and gradually retard the spark when the engine is slowed down by work, always just keeping ahead of the knock. If the engine speed decreases, either from closing the throttle or excessive work, the spark must be retarded or the engine will pound or knock, as the explosions tend to force the pistons and crank-shaft in the wrong direction.

179. What is meant by the range of advance and retard?

The number of degrees advance or retard effective on an engine depends on the range or movement of the timing lever and the relation of magneto speed to engine speed.

180. A magneto, driven at ½ engine speed having a range of 25 degrees of the timing lever, how many degrees effective on the engine?

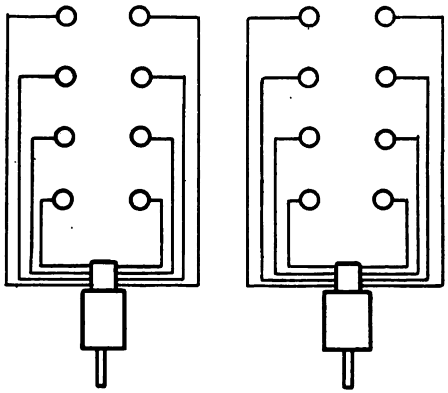
50 degrees.

181. A magneto driven at engine speed, having a range of 30 degrees of the timing lever, how many degrees effective on the engine?

30 degrees.

182. A magneto driven at 1½ times engine speed, having a range of 40 degrees of the timing lever, how many degrees effective on the engine?

26.66 degrees.



Magneto ignition system, 8 cylinder Vee engine, the units comprise two high-tension magnetos, each one firing two spark plugs in each cylinder on separate engine blocks.

183. What is the relation of spark advance to piston travel?

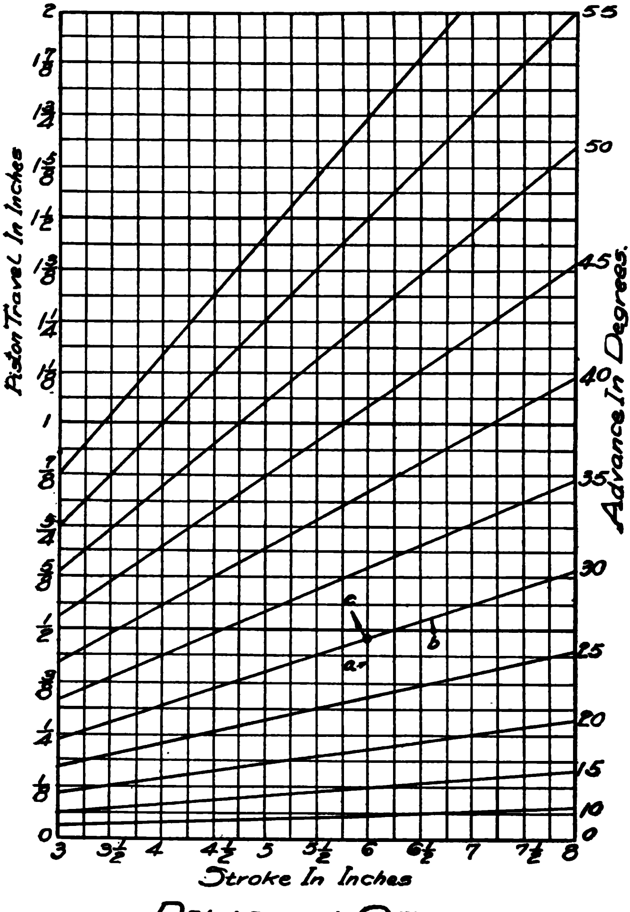
To ascertain the relation of spark advance in degrees to piston travel in inches, it may be calculated by means of the accompanying chart, in which the horizontal lines represent the piston travel in fractions of an inch and the vertical lines the

stroke in fractions of an inch. It is arranged for engines having strokes from 3 to 8 inches, the ratio between the crank and connecting rod length being 1 to 4.5.

To find the piston travel for an advance of 30 degrees in an engine having a stroke of 6 inches, the vertical line *a*, is traced upward until it intersects the diagonal line designating 30 degrees at *c*, following this to the left it will be noticed that the intersecting point is just below the ½ inch division line, or approximately .46 of an inch. An engine with a stroke of 6 inches running at 1800 r.p.m., its piston would be traveling 1800 feet per minute (i. e. stroke doubled or 1 foot per revolution), 30 feet, or 360 inches per second, so that each inch of the stroke would be covered at an average speed of 1 inch in 1/360 of a second, and the ½ inch in 1/720 of a second, from which it will be seen that spark advance is necessary.

184. What effect would a small amount of lag in a magneto have?

In an armature type of magneto sparking a six cylinder four stroke cycle engine, running at a speed of 1800 R.P.M., when the speed of the engine is 1200 R.P.M., the current must rise from zero to its maximum value and drop back to zero again 3600 times per minute or 60 times per second. The current has 1/60th part of a second to rise to its maximum and drop back again. A lag of 1/1200th part of a second corresponds to 1/40th of a revolution or 9 degrees of crank travel.



RELATION OF SPARK ADVANCE TO PISTON TRAVEL

185. What is the relation of magneto speed to engine speed?

The relation of magneto speed to engine speed is proportional to the number of sparks required per revolution of a four stroke cycle engine.

Cylinders	Magneto sparks per 360 degrees	Magneto Speed in relation to engine speed
1	1	½
2	2, distributor on collector spool	½
2	1, distributor spaced 180 degrees	engine speed
3	1	1½
4	2	engine speed
6	2	1½
8	2	2
8	4	engine speed
12	2	3
12	4	1½
12	6	engine speed

186. What is the relation of speed of the magneto shaft to the distributor shaft?

A four cylinder magneto 2 to 1. A six cylinder magneto 3 to 1. An eight cylinder magneto producing four sparks per revolution 2 to 1. An eight cylinder magneto producing two sparks per revolution 4 to 1. A twelve cylinder magneto producing four sparks per revolution 3 to 1.

187. How would you detect the failure of the ignition?

There would be no spark at the spark plugs.

188. What would cause a magneto to spark at the safety gap, when the high-tension circuit is in good order?

Sparking at the safety gap is an indication that there is a gap in the secondary circuit greater than the resistance of the secondary winding, as for instance spark plug electrodes burning too far apart.

189. What is a safety gap?

An auxiliary path of the high-tension current to protect the winding, and insulating parts of the magneto, when the high-tension current cannot discharge itself through the spark plug gap, as for instance if a spark plug cable became disconnected.

190. When an engine will not start but fires once or twice and then stops, the flywheel rocking back and forth, what is the cause?

Some of the spark plug leads have been misplaced, so that after one or two explosions, the next one takes place out of sequence.

191. How would you test for trouble in a high-tension magneto ignition system?

See that the magneto ground or short-circuiting switch and wiring are in good order, see that the platinum contact points of the circuit breaker are breaking properly and at the correct time, if the

points flash, a defective condenser or oil on the points may be suspected, see that the distributor brushes are not broken and in good contact on the segment, see that the cables leading to the spark plugs are not grounded, chafed or cut, see that the spark plugs are in good condition.

192. What is pre-ignition?

Pre-ignition is the result that, in the combustion chamber, a particle of carbon or some projection inside of it has become overheated, permitting a too early ignition of the compression of the gaseous mixture.

193. What is necessary to keep the magneto in good running condition?

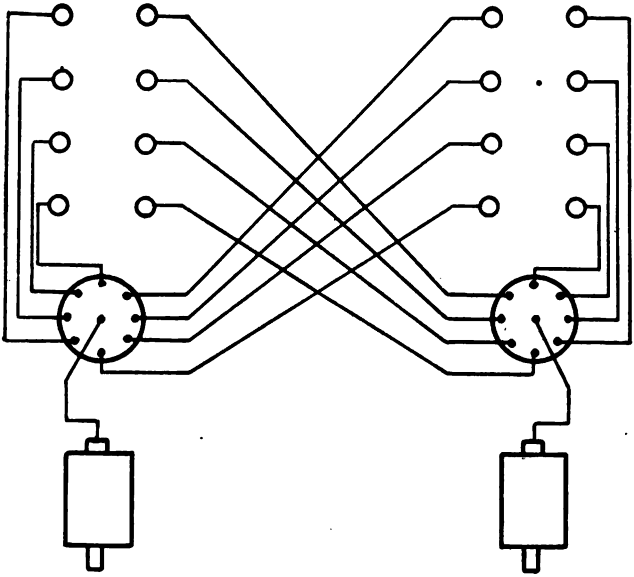
Lubricate it at proper intervals, keep it clean, especially the platinum contact points and distributor, also keep it dry. This is about all anyone should do, unless a skilled mechanic, it is unwise to tamper with the instrument in case of trouble, send it to a service station.

194. How often should a magneto be oiled?

The importance of oiling depends entirely upon the service required from a magneto, on automobiles, every 1000 miles, on motor trucks, every 50 hours of operation, on airplanes, every 25 hours of operation is a good rule.

195. What are the advantages of an Auxiliary vibrating system?

To assist the starting of hand cranked engines in cold weather.



Magneto ignition system, 8 cylinder Vee engine, the units comprise two high-tension magnetos, cross-connected, firing two spark plugs in each cylinder.

196. What does an auxiliary vibrator system consist of and how does it operate?

The auxiliary vibrator system consists of a vibrator, two small windings and a condenser, all housed within the switching device. The battery current is carried through the vibrator to the circuit

breaker of the magneto; the high-tension current being distributed to the spark plugs through the distributor on the magneto. When the switch lever is placed on the battery position, the current from the battery is conducted through the vibrator windings to the vibrator and to the primary winding of the magneto. The vibrator is simultaneously set into operation with throwing the switch lever on battery, but no sparks are produced at the plugs until the cam separates the platinum points, thereby bringing the magneto primary winding into the circuit. A continuous shower of sparks is produced in that period of time in which the platinum points are held open by the cam.

197. What are the characteristics of a rotary engine?

The steady running of a rotary engine is due to the fact that there are literally no reciprocating parts in the absolute sense, the apparent reciprocation between the pistons and cylinders being solely a relative reciprocation, since both travel in a circular path.

The master rod in a rotary engine, is the connecting rod that is vertical when the crankshaft is in a vertical position.

A seven cylinder rotary engine has power impulses spaced 102.8 degrees apart and requires a magneto giving two sparks per revolution, driven at 1¾ times engine speed.

The firing order of a seven cylinder rotary engine is as follows;

1—6—4—2—7—5—3.

A nine cylinder rotary engine has power impulses

spaced 80 degrees apart and requires a magneto giving two sparks per revolution, driven at 2¼ times engine speed.

The firing order of a nine cylinder rotary engine is as follows;

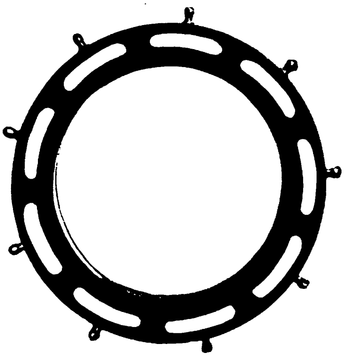
1—3—5—7—9—2—4—6—8.

Magneto for rotary engine.

The rotary engine type of magneto is usually mounted in an inverted position and gear-driven. A short cable having detachable terminals connecting with the magneto at one end and with the high-tension brush-holder at the other end, the carbon brush of the brush-holder bears against the segmented face of a separate distributor.

198. What is the relation of magneto speed to engine speed on a 9 cylinder rotary engine, the magneto giving two sparks per revolution?

In a 9 cylinder rotary engine the power impulses are spaced, 720 degrees divided by 9 or 80 degrees apart, consequently a spark is required every 80



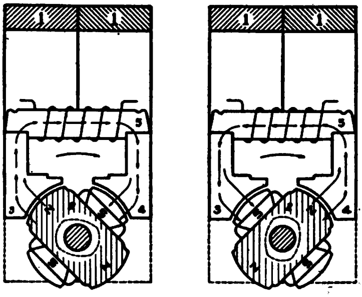
Distributor of a 9 cylinder rotary engine, it rotates with the engine, the distributor segments being connected to the spark plugs with bare brass wires.

Magneto high-tension terminal, detachable cable and brush holder, rotary engine.

degrees, with a magneto giving a spark every 180 degrees, it follows that, 80 divided by 180 equals magneto speed, therefore the magneto must be driven 2¼ times engine speed.

199. What is the principle of operation of a unidirectional polar inductor magneto?

A.—The magnetic flux flows in one direction thru core 5. When wing N is opposite 3, flux flows to 3 and thru 5 to 4, back to wing S of opposite polarity. Until the wing N has passed the leaving pole piece 3, the action of the cam 6 holds the platinum contacts of the breaker apart, thereby preventing current from being induced in the primary winding on core 5, leaving the core free from magnetic interference and preparing it for a powerful magnetic and electrical action when the polarity of the pole pieces and core is reversed upon further rotation.



A B

B.—The magnetic flux flows in the reverse direction thru core 5. Wing N has moved over to 4 and the direction of the flow of flux is reversed, now flowing from 4 thru 5 to 3. When wing S passes

the leaving pole piece 3, the action of the cam 6 opens the platinum contacts of the circuit breaker, breaking the primary current in the winding on the core 5.

200. What are the characteristics of magneto ignition on the Liberty engine?

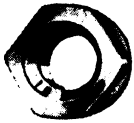
Twelve-cylinder, Vee-type engine with cylinders set at an angle of 45 degrees.

The cylinders fire at 45 and 75 degrees, respectively, alternately on each engine block, the cranks being 120 degrees apart.

The magneto ignition developed comprises two high-tension synchronized magnetos, driven at 1½ times engine speed.

The magneto generates six impulses per revolution, two of which are used to free the core from magnetic interference, consequently only four sparks are produced.

The cam lobes are spaced 67½, 112½ degrees respectively.



Cam.

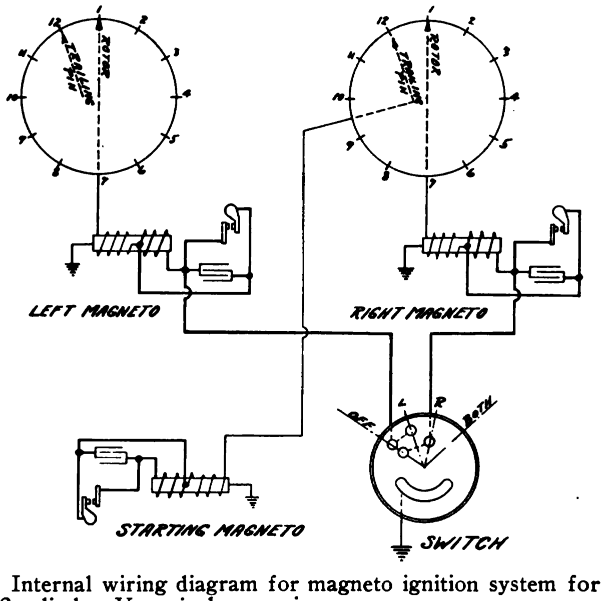
The distributor is integral with the magneto, it is of the spark gap type with a serrated rotating part, separated .015 of an inch from the serrated segments in the distributor block. The segments are spaced 22½ and 37½ degrees respectively.

The rotating distributor member is driven at 1/3 magneto speed.

The magnetos are fixed spark, timed 24.5 degrees ahead of dead center.

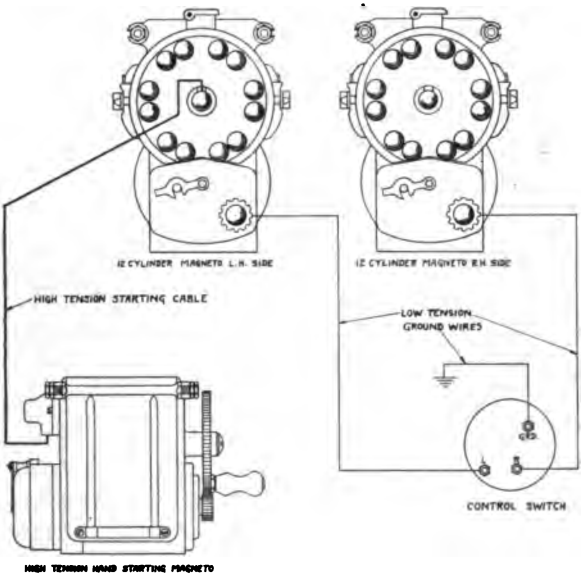
There are two complete systems of ignition, each magneto will fire the engine separately.

The switch connections permit either or both magnetos to operate, or cut out either magneto or both.

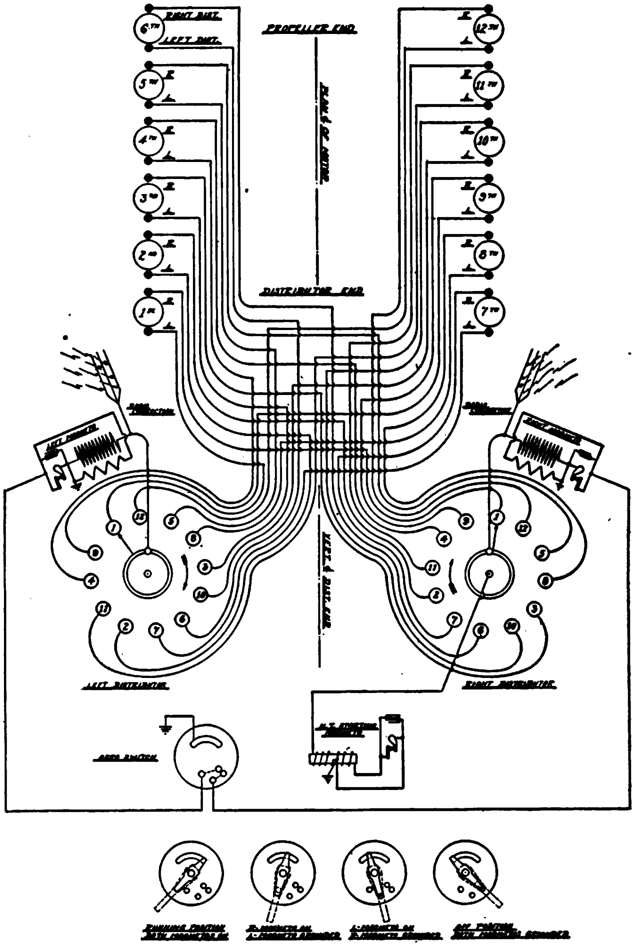


Internal wiring diagram for magneto ignition system for 12 cylinder, Vee, airplane engine.

An auxiliary hand-cranked starting magneto giving 16 sparks per revolution is connected to the right-hand distributor and fires on the trailing pin to the distributor 5 degrees late or after upper dead center.



External wiring plan of magneto ignition system for 12-cylinder Vee airplane engine.



Wiring plan of magneto installation on the Liberty engine, with two service magnetos equipped with radio terminals, the magnetos are connected to separate distributors and a starting magneto is utilized.

201. What are the characteristics of battery-timer ignition on the Liberty engine?

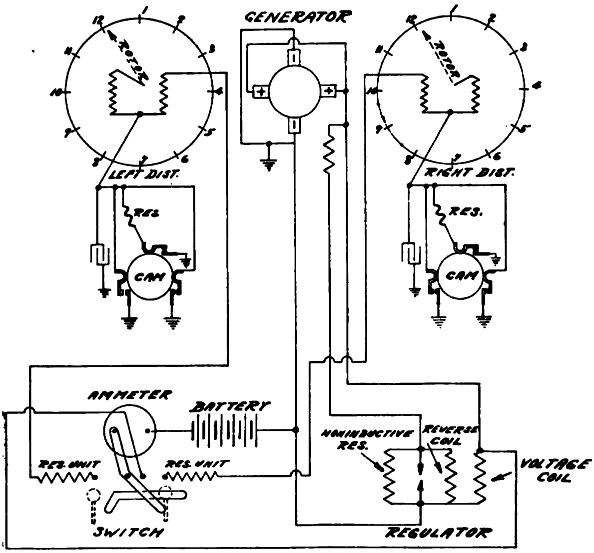
The system consists of a generator, current and voltage regulator, two circuit breakers, two distributors with integral coils having a low- and high-tension winding, a storage battery, ammeter for indicating battery charge and discharge and a control switch.

The generator is of the direct current shunt wound 4 pole type, the voltage is controlled by a regulator consisting of vibrator actuated by an electro-magnet across the line, when the generator voltage exceeds a predetermined amount, the vibrator armature is attracted and the contact broken, thereby removing a short circuit around another coil and reducing the current through the generator field which reduces the line voltage. The second coil is wound on the same core of the regulator, but of opposite polarity, when the short circuit is removed from around this coil, it demagnetizes the core and permits the vibrator to fall back, by this means the generator voltage is maintained between 10½ and 11 volts. A noninductive resistance is connected across the vibrator contacts to prevent arcing.

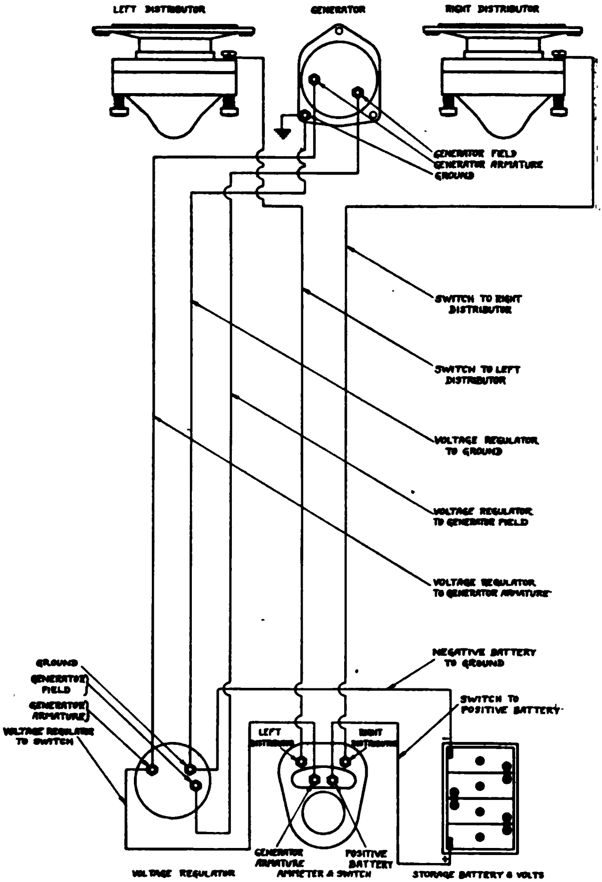
The generator is not connected to the battery until both switches are on, but either one connects one timer-distributor with the battery.

The service breakers are connected in parallel and open at the same time in proper rotation, safety breaker opens first and takes out the resistance, if the engine is turned in the reverse direction, the safety breaker stays closed and the 10 ohm resist-

ance prevents a spark at the plug. Service breakers open .010 to .013. Safety breaker opens .013 to .015.



Internal wiring diagram of generator battery ignition system.



External wiring diagram generator battery ignition system.

One ignition unit is used when engine is running below 700 R. P. M., the current being obtained from the battery.

Above 700 R. P. M., both units are switched in, battery and generator in the circuit.

202. What is an impulse starter as applied to a high-tension magneto?

An impulse starter is designed to make the starting of even the largest engines directly from the magneto safe, sure and easy. It is a purely mechanical device and operates as follows: the rotating unit consists of the magneto member and cam member, the magneto member is keyed to the magneto shaft, the other member telescopes into the magneto member and is retained by the shaft nut and washer. Each member has a lug riveted into it and projecting into the annular

Impulse starter for a high-tension magneto.

space between the two members. Compressed between the two lugs are two springs, one long actuating spring and one short cushion spring. The magneto member has two notches cut in its periphery, the pawl engaging the notches of this member. The stationary unit consists of a flat plate attached to the magneto or it may be in a housing at the drive end of the magneto for the enclosed type. Above the rotating unit the plate

carries two pins connected by a link for right-hand rotation, the pawl is on the right-hand pin, if for left-hand rotation, on the left-hand pin. The pawl is held in either the engaging or disengaging position by a small plunger passing through a compression spring. When the engine is to be started the pawl is thrown in the operating position by pressing it toward the center of the magneto.

When the engine is turned forward, the rotating unit rotates. The pawl engages the magneto member in one of the notches and arrests the movement of that member, this also stopping the movement of the magneto shaft. But the cam member of the rotating unit, being driven by the shaft and flexible joint, continues to revolve. The long actuating spring between the two members is compressed.

The driven member continues to rotate until the cam, which is integral with it, reaches the pawl.

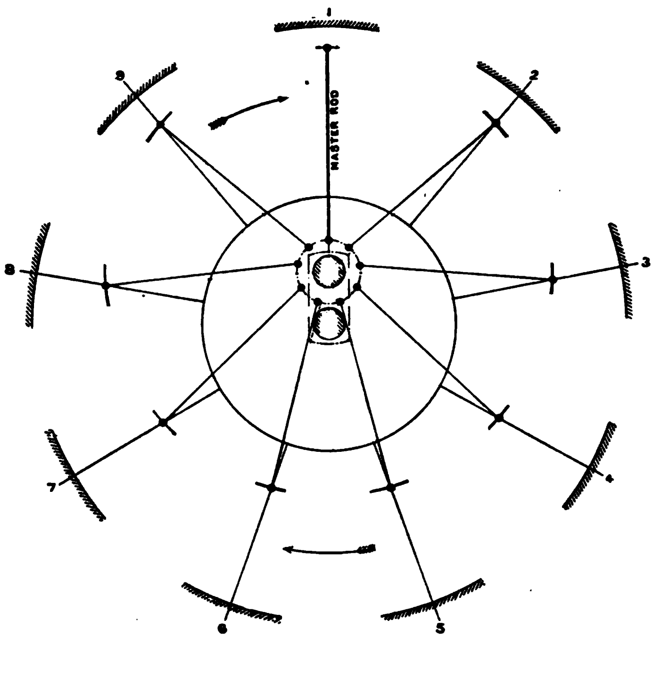
This cam forces the pawl out of the notch. The compressed spring expands and throws the magneto member and the magneto rotor forward at a several hundred-revolutions-per-minute rate until the two members reach their former relative positions. The short cushion spring absorbs the shock and brings the rapidly moving magneto member to a stop gently.

During this rapid forward movement of the magneto rotor, the breaker points of the magneto separate and a hot intense spark is produced in

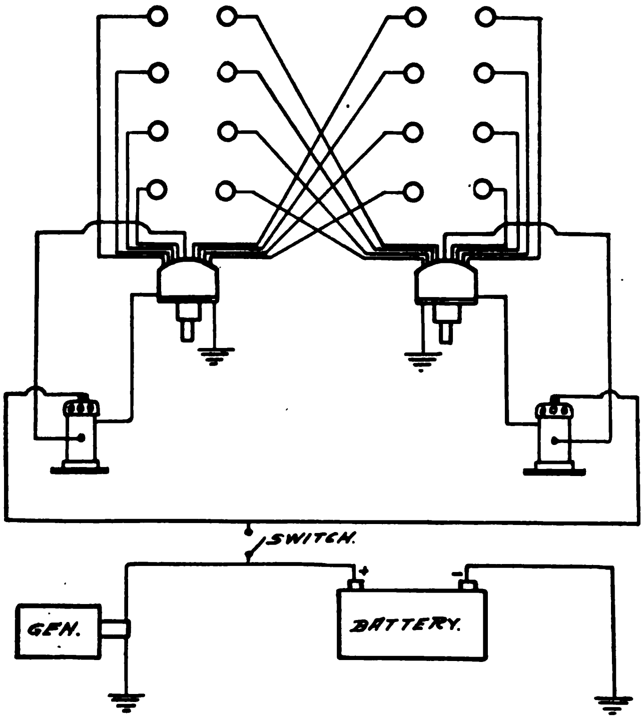
that cylinder whose piston is then in the firing position.

This spark has the same intensity as that produced when the magneto is running at full engine speed and consequently starts the engine even under conditions not the most favorable to good combustion.

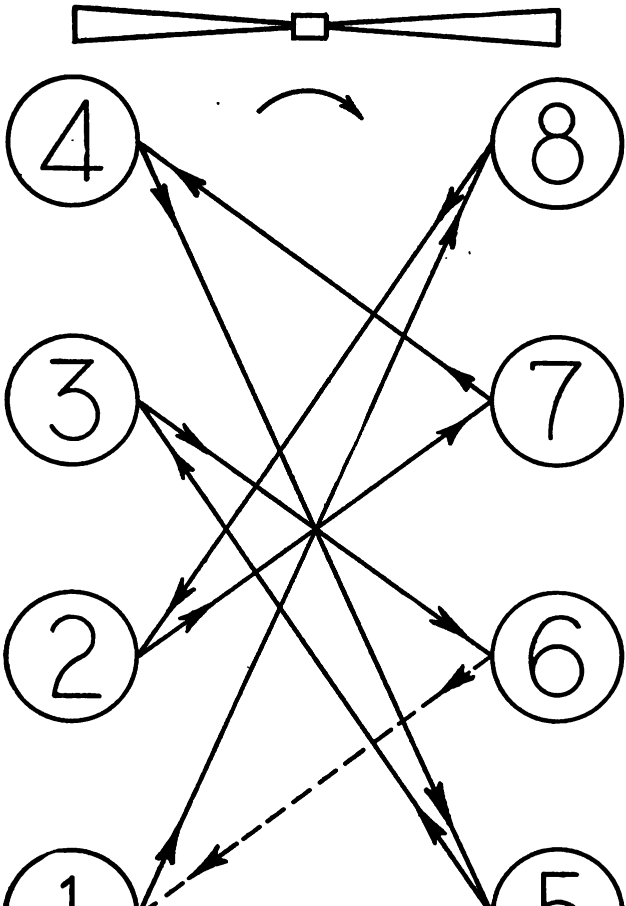
The shape of the pawl and of the notch is such that when the engine starts and comes up to a speed of about 200 to 250 r. p. m., the pawl is thrown outward with such force that it is caught and held in the inoperative position. The driven member then drives the magneto member positively and at the same speed as the engine. The coupling then has no effect whatever on the spark but acts as a common magneto drive coupling.



9 cylinder rotary engine, outline of relative positions of pistons and connecting rods. No. 1 cylinder about to fire, master rod in the vertical position.

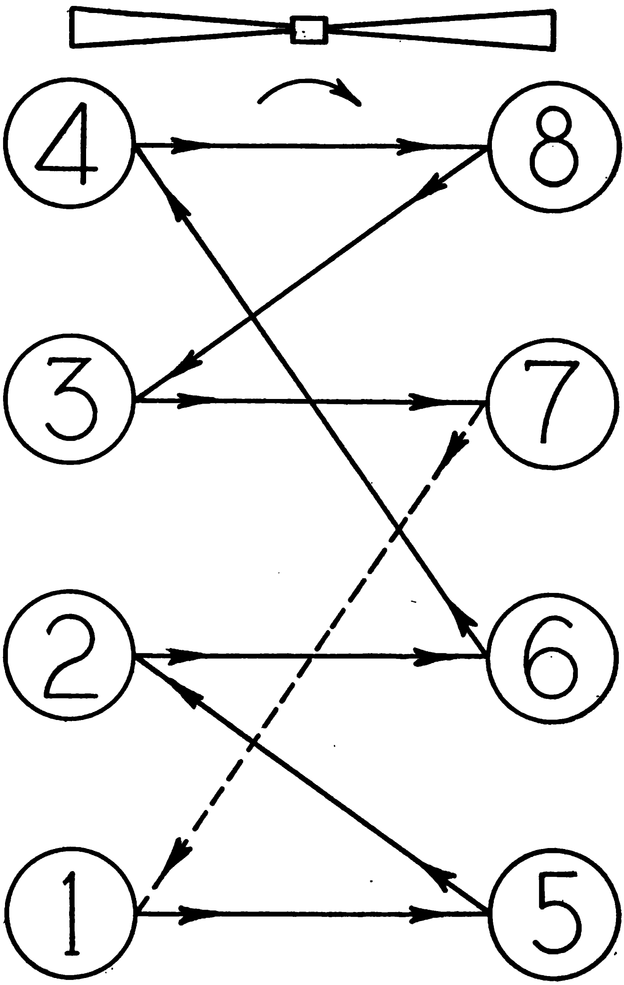


Battery timer ignition system, 8 cylinder Vee engine, the units comprise a generator, storage battery, two circuit breakers, two cross-connected distributors, firing two spark plugs in each cylinder.

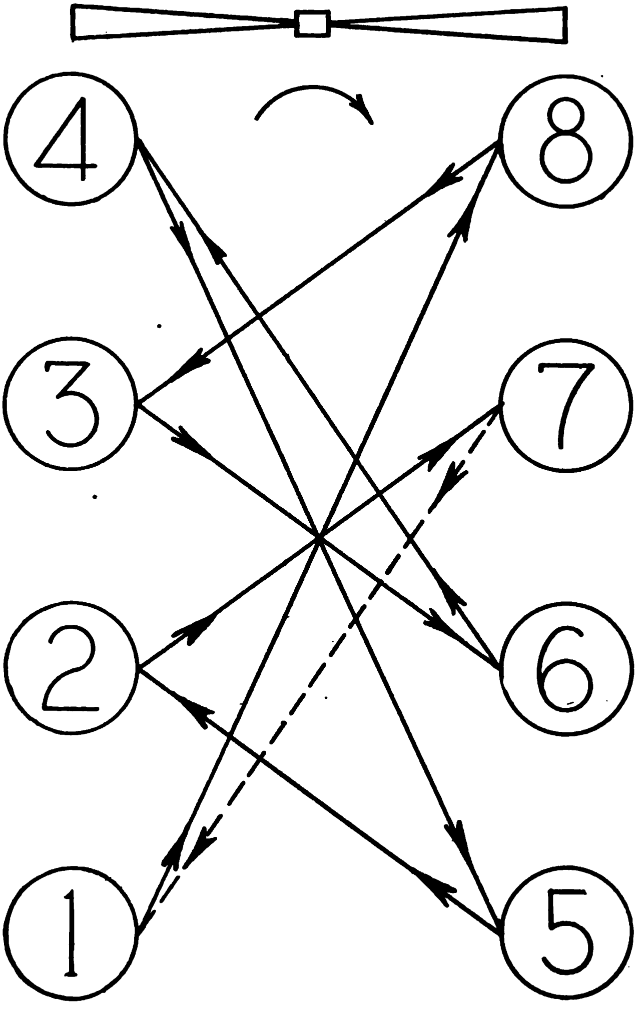


Firing order Hispano-Suiza 8 cylinder Vee engine, viewed from pump end: 1L—8R—2L—7R—4L—5R—3L—6R.

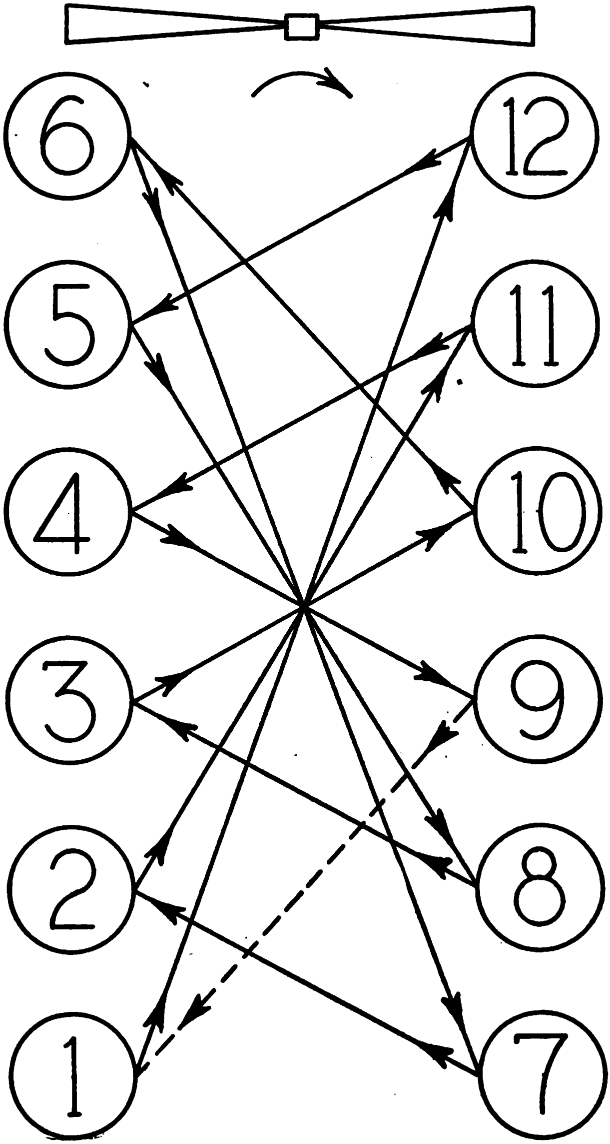
Manufacturer's firing order from propeller end: 4L—5R—3L—6R—1L—8R—2L—7R.



Firing order Curtiss 8 cylinder Vee engine OX2:
1L—5R—2L—6R—4L—8R—3L—7R.



Firing order, Sturtevant 8 cylinder Vee engine:
1L—8R—3L—6R—4L—5R—2L—7R.



Firing order Liberty 12 cylinder Vee engine: 1L—12R—L—8R—3L—10R—6L—7R—2L—11R—4L—9R.

TYPICAL AVIATION ENGINES DEVELOPED DURING THE YEARS 1914 TO 1919.

UNITED STATES

Hispano-Suiza	Thomas-Morse
Curtiss	Van Blerck
Liberty	Knox
Hall-Scott	Bugatti
Dusenberg	Kirkham
Sturtevant	Harry A. Miller
Aeromarine	Sterling Motor Co.
Wisconsin	Gnome
Union Gas Engine	Le Rhone
Atwood	Orlo

ENGLISH

Rolls-Royce	Beardmore
Sunbeam	Wolsely
Napier "Lion"	

FRENCH

Renault	Hispano-Suiza
Salmson	Lorraine-Dietrich
Clerget	Peugeot
Gnome	Panhard-Levassor
Le Rhone	Bugatti
Anzani	

ITALIAN

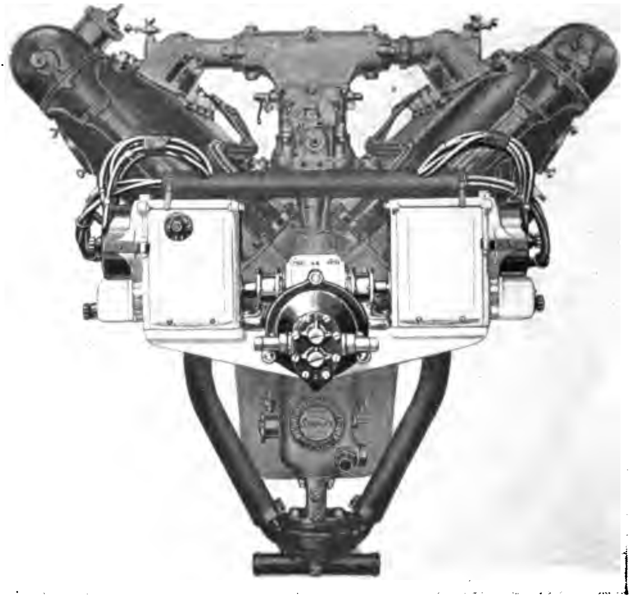
Fiat	Isotta-Frashini
Lancia	Ansaldo

GERMAN

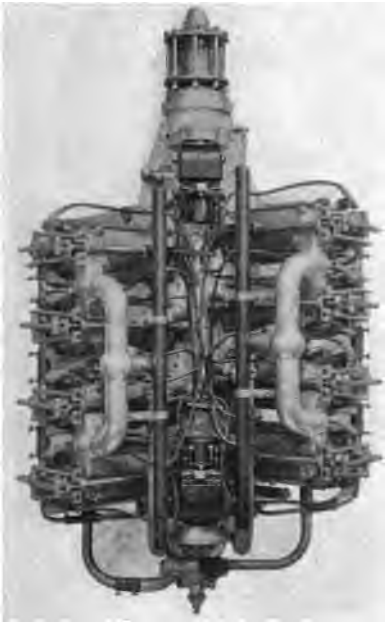
Mercedes	Maybach
Benz	

AUSTRIAN

Hiero (Warchalowski)	Austro-Daimler



Hispano-Suiza, 180 H. P., 8 cylinder, 90 degree, Vee engine.

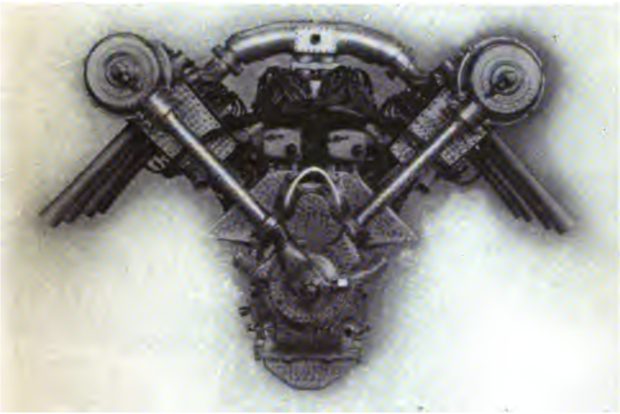


Curtiss, 100 H. P., 8 cylinder, 90 degree Vee engine.

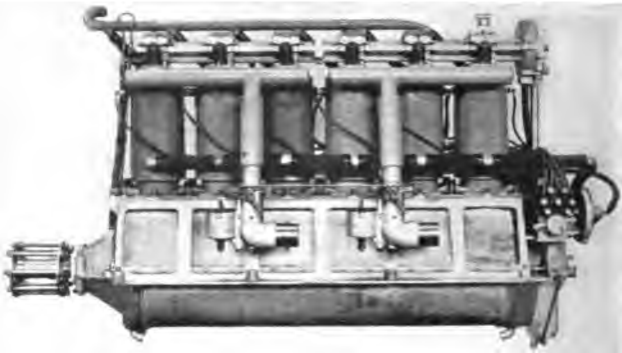
Hall-Scott, 450 H. P., 12 cylinder, 60 degree, Vee engine.

Hall-Scott, 150 H. P., 6 cylinder, vertical engine.

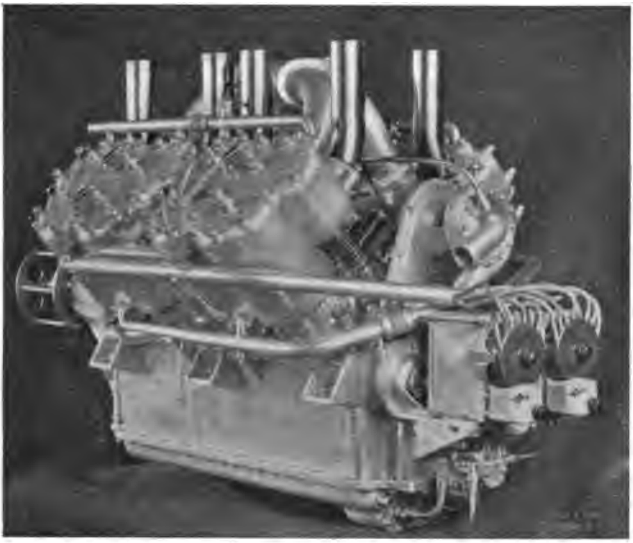
Sturtevant, 210 H. P., 8 cylinder, 90 degree, Vee engine.



Aeromarine, 150 H. P., 8 cylinder, 90 degree, Vee engine.

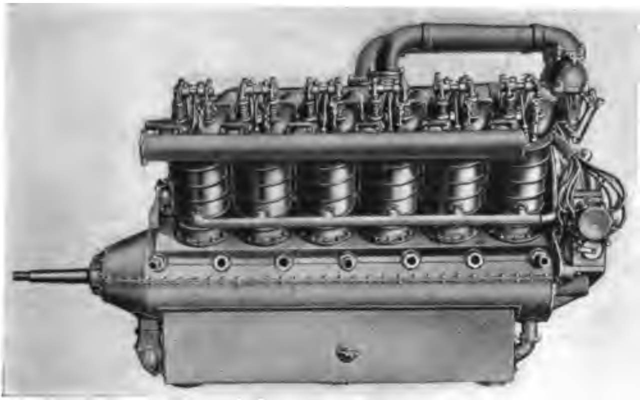


Union gas engine, 120 H. P., 6 cylinder, vertical engine.

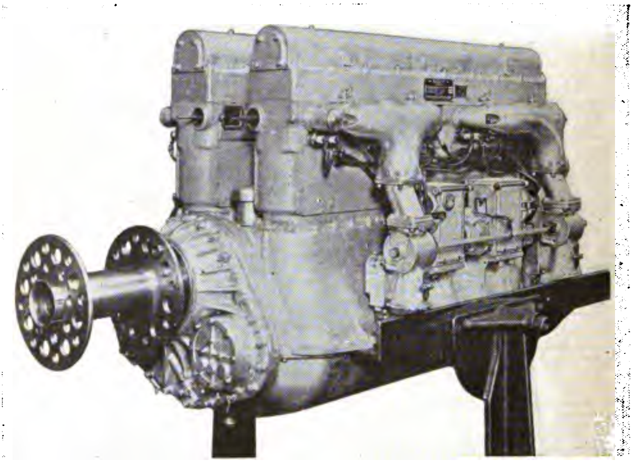


Thomas-Morse, 250 H. P., 8 cylinder, 90 degree Vee engine. Side view.

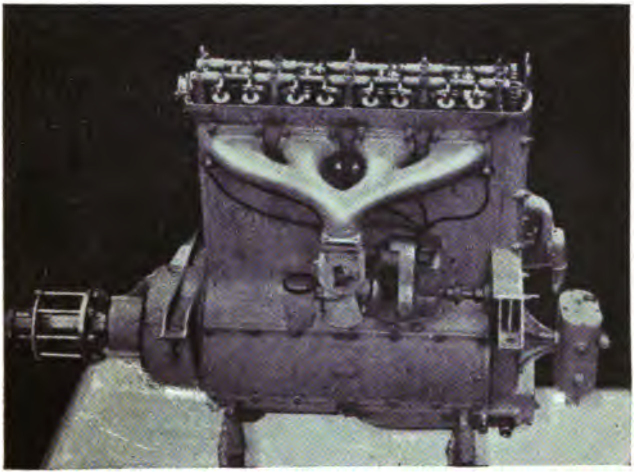
Thomas-Morse, 250 H. P., 8 cylinder, 90 degree Vee engine. End view.



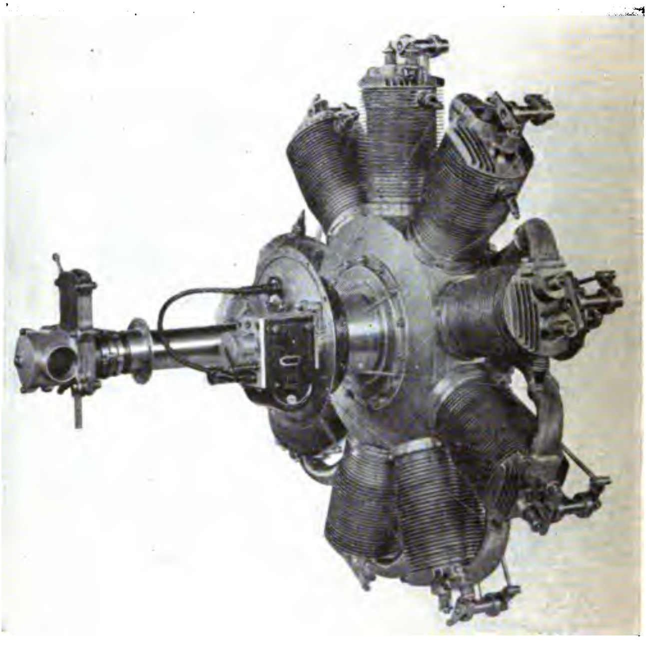
Van Blerck, 150 H. P., vertical engine.



Bugatti, 410 H. P., 16 cylinder, vertical engine; 2 rows of 8 cylinders in blocks of 4.

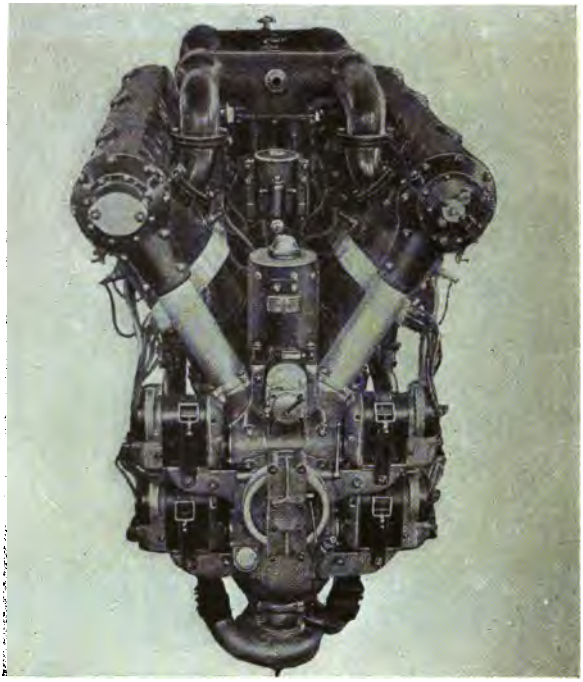


Miller, 125 H. P., 4 cylinder, vertical engine.

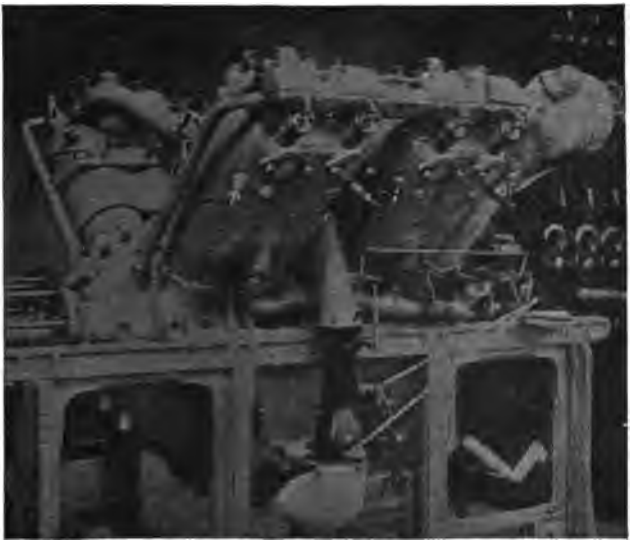


Le Rhone, 80 H. P., 9 cylinder, rotary engine.

Napier "Lion," 450 H. P., 12 cylinder, 60 degree engine; 3 blocks of 4 cylinders.

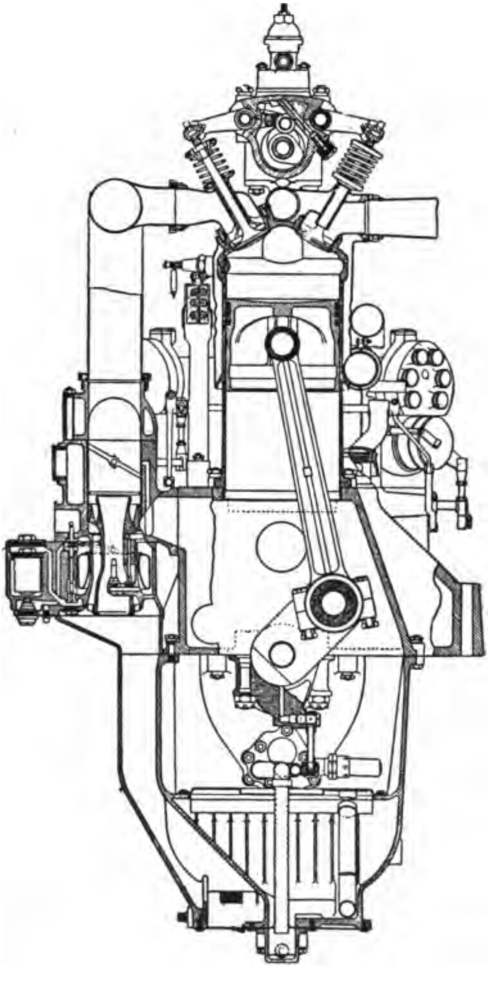


Renault, 650 H. P., 12 cylinder, 60 degree, Vee engine.



Lorraine-Dietrich, 275 H. P., 8 cylinder, 90 degree, Vee engine.

Ansaldo, 220 H. P., 6 cylinder, vertical engine.



Austro-Daimler, 200 H. P., 6 cylinder, vertical engine. Sectional view.

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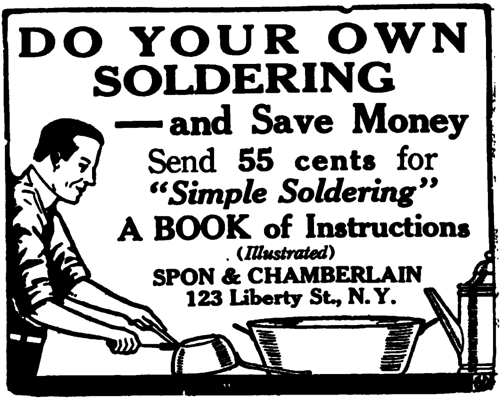

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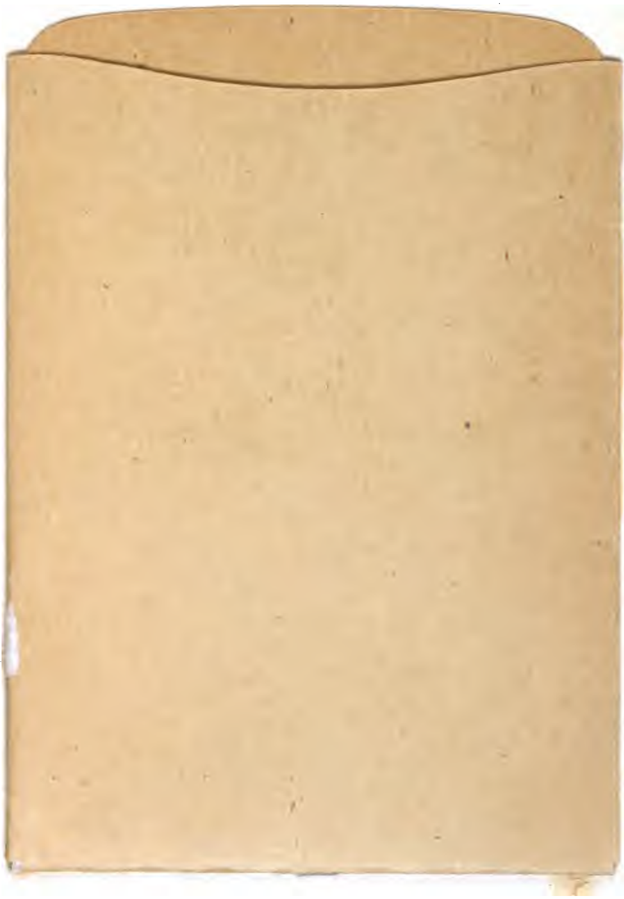

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